FISHERY MANAGEMENT INVESTIGATIONS

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Abstract

Concentrations of American White Pelican *Pelecanus erythrorhynchos* in the up-reservoir portion of Anderson Ranch Reservoir were thought to be deterring kokanee from migrating to spawning areas in the South Fork Boise River. To ensure adequate kokanee recruitment, staff actively hazed Pelicans 107 times during September 6-16, 2016. Pyrotechnics were used to deter pelican foraging. Flock size was greatest at the onset of the hazing efforts (150-170 pelicans), then decreased to 60-80 pelicans as hazing continued. Multiple hazing efforts occurred daily often focusing on smaller groups of 2-30 Pelicans. Hazing efforts were ephemeral rarely leading to permanent deterrence. Pelican tolerance to all pyrotechnics increased through the hazing effort. Results from counts of spawning kokanee upstream from the conflict area were inconclusive.

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Introduction

Anderson Ranch Reservoir (ARR) is a 22.5 km-long Bureau of Reclamation (BOR) impoundment of the South Fork Boise River (SFBR) in Elmore County, Idaho. Dam construction was completed in 1950. Spillway elevation is 1,279 m above sea level. The reservoir has a maximum storage capacity of 493,180 acre feet with approximately 28,980 acre-feet of dead storage. Maximum depths reach approximately 91 m.

The primary purpose of the dam is for irrigation, power production, and flood control. Recreation on this reservoir is managed by the Boise National Forest. There are six boat ramps including Deer Creek, Pine, Fall Creek, Castle Creek, Curlew Creek, and Elk Creek. The Curlew Creek access receives the majority of use. Anglers fishing ARR target mostly kokanee *Oncorhynchus nerka*, Rainbow Trout *Oncorhynchus mykiss*, Smallmouth Bass *Micropterus dolomieu*, fall run Chinook *Oncorhynchus tshawytscha*, and Yellow Perch *Perca flavescens*. Bull Trout *Salvelinus confluentus* are present seasonally, but rarely targeted by anglers.

Kokanee are managed to provide harvest opportunity with a daily bag and possession limit of 25 and 50 fish, respectively. In most years, natural recruitment of kokanee fully supports the reservoir fishery. Most spawning is thought to occur in the SFBR with unknown contribution from other large tributaries. Recent forest fires and subsequent debris flows in the SFBR drainage may have reduced kokanee recruitment to the reservoir. The management objectives for ARR kokanee are to provide catch rates of 1.0 fish/h with mean length greater than 305 mm.

Reports of loafing American White Pelican *Pelecanus erythrorhynchos* (herein referred to as pelican) exhibiting foraging behavior at the up-reservoir portion of ARR started in 2014. Upon investigation, 40-50 pelicans were observed foraging at the mouth of the SFBR where it enters ARR, and while kokanee were staging to initiate spawning migration. Based on high kokanee abundance estimates in ARR and the relatively small flock size of Pelicans, staff determined their feeding was not likely a population concern for kokanee and did not haze in 2014.

Flock size frequenting the area in the fall has increased with observation of up to 300 pelicans in 2016. Due to low water conditions and higher pelican counts in 2016, staff became concerned that avian predation may substantially reduce the number of kokanee spawners; ultimately reducing the reservoir's kokanee population. Under such circumstances, IDFG's current American White Pelican Management Plan recommends actions to reduce or eliminate avian predation using non-lethal techniques (IDFG 2016).

Several management options presented in the IDFG Pelican Management plan were considered but were deemed impractical in this situation. Manipulating reservoir storage levels, modifying Pelican forage options, modifying stocking strategies, installing physical barriers for prey refugia, or installing bird lines were not feasible at this location. IDFG does not have water management jurisdiction. The area of greatest impact (e.g. the SFBR outlet into ARR) is a shifting, unstable river delta and not suitable for constructing infrastructure. Modification of stocking strategies could not address the immediate conflict nor are there alternative forage options available that would buffer or protect fall spawning kokanee. Therefore, the most feasible and efficient option available was to directly haze pelicans at the conflict area. Therefore, the objective of this effort was to maximize kokanee escapement by reducing or eliminating avian predation on staging and spawning kokanee.

Methods

An IDFG fisheries technician was stationed on location from September 6-16, 2016. During this period, IDFG staff hazed feeding and loafing pelicans six days per week prioritizing 1800-2400 h since kokanee migration largely occurs during nighttime and pelicans forage nocturnally (McMahon and Evans 1992). Opportunistic hazing also occurred during the early morning and mid-day. Hazing occurred in the mud flat within the drawn-down zone of the reservoir at the mouth of the South Fork Boise River (Figure 1).

Pyrotechnics were used to invoke fright responses to deter pelican foraging in conflict areas. Staff deployed cracker shells (shotgun and pistol), M-100s, blue whistler rockets, red whistler rockets, and smoke-rope setups using M-100s. Smoke ropes combined with M-100 pyrotechnics were used to provide a random-interval and prolonged disturbance while allowing the staff to haze other groups of pelicans in different areas.

With each effort, staff recorded the date, location, number of pelicans being hazed, number of tagged pelicans observed, pre-hazing activity, post-hazing response, and the pelicans' overall response to the hazing effort.

Spawning kokanee were surveyed in the SFBR prior to and during the hazing effort to evaluate hazing effects. Spawning kokanee were counted at seven fixed locations on September 1, 9, and 16, 2016. These visual counts were considered an abundance index and were used to qualitatively evaluate effects of hazing.

Results and Discussion

Pelicans were hazed a total of 107 times from September 6 to 16, 2016. Flock size was largest at the onset of the hazing efforts (150-170 pelicans), then decreased to a recurring flock size of 60-80 pelicans. Multiple hazing efforts occurred on a given day often focusing on smaller flocks that ranged from 2-30 pelicans.

Long-ranged pyrotechnics were the most effective deterrent. The terrain in the area precluded ambush-style hazing where short-ranged pyrotechnics could be useful. Pelicans observed approaching staff and made subtle efforts (swim or short flights) to maintain distance between themselves and staff. Rockets with boosters were the only pyrotechnic that could reach the pelicans and invoke a substantial fright response (e.g. extended flight).

Hazing efforts rarely resulted in pelicans leaving ARR entirely. Pelicans often avoided an area after a hazing event but returned shortly after active hazing ceased. For this reason, smoke ropes with embedded M-100 explosives were deployed after an active hazing effort. The smoke ropes burned slowly igniting the M-100s at random intervals, which proved effective at disrupting pelican foraging in the absence of active hazing efforts. Pelican tolerance to all pyrotechnics use increase throughout the hazing effort.

Results from counts of spawning kokanee upstream from the conflict area were inconclusive. Cumulative counts were 45, 64, and 89 on September 1, 9, and 16, 2016, respectively (Table 1). These counts showed an abundance increase that correlated with hazing; however, those results were skewed in large part by one survey location (Location 10) where the positive correlation was most pronounced. Additionally, any correlation increase may have been biased from intermittent spawn run timing. The remaining five locations showed negative or neutral correlations.

Hazing efforts may have occurred too late. The scarcity of spawning kokanee detected while monitoring the SFBR upstream of the hazing area suggests reservoir densities were extremely low and/or hazing occurred at the end of the spawning run. Counts of kokanee spawning in 2016 were drastically lower than expected based on past observations at a picket weir located near Pine, ID. Reports of larger numbers of foraging pelicans (~300 pelicans) in August 2016 suggest the kokanee availability and foraging opportunity may have been high prior to this hazing effort. In addition, IDFG staff reported fewer staging and migrating kokanee after the first week of operations, even after hazing began. Hazing may have been more effective had it been initiated earlier and aligned more closely with the timing of 2016 kokanee spawning run. Better monitoring of pelican presence and abundance as well as kokanee escapement beginning in July would improve the efficiency of these efforts and allow for better effectiveness monitoring.

The IDFG Pelican Conservation Plan directs staff to consider altering stocking programs to minimize Pelican predation. One option would be to stock late run kokanee that spawn in late October when most pelicans have migrated south. The intent would be to delay spawning escapement until after pelicans migrate to their winter habitats. In addition, delayed escapement might also extend the ARR kokanee fishery into August and September. However, late run kokanee may have performance traits (flesh quality, growth, survival) that make them less desirable from other standpoints. Furthermore, Idaho has few large, early run kokanee populations capable of supporting egg takes if needed. Therefore, establishing late run kokanee to avoid pelican predation or to reduce hazing needs is not likely appropriate, desirable, or practical.

Management Recommendations

1. We recommend using long-range pyrotechnics combined with smoke rope (M-100) explosives for future efforts.
2. Monitor pelican abundance and kokanee escapement at the mouth of the SFBR starting in July. Use information to inform the need to haze, time to initiate, and assess effectiveness.
3. Develop a fixed-site monitoring protocol to evaluate kokanee escapement related to effects of hazing.

ANDERSON RANCH RESERVOIR

Abstract

Examination of angler creels at Anderson Ranch Reservoir allows collection of biological and fisheries information that may improve understanding and management of this popular fishery. We ran an angler check station at the Curlew boat ramp on 16 randomly chosen dates between June 24 and August 7, 2016. In all, 221 anglers were interviewed that fished for a combined total of 1,121 h. Trip time averaged 5.1 h and ranged from 1 to 10 h. Kokanee *Oncorhynchus nerka* catch ranged from 0 to 12 and averaged 1.3. Catch rate ranged from 0 to 5.5 fish/h with an average of 0.3 fish/h. Nearly all kokanee caught were harvested and therefore catch and harvest statistics were similar. Harvest ranged from 0 to 11 with an average of 1.2. Catch rate that ranged from 0.0 to 5.5 fish/h with an average of 0.3 fish/h. Harvested kokanee ranged from 230 to 603 mm TL and averaged 416 mm. Based on the 2016 angler check station results, management goals are only partially being met. The mean catch rate of 0.3 fish/h was less than the management target of 1.0 fish/h.

The kokanee population was sampled using three methods including two trawl nets of differing dimensions and horizontal gill nets. The combined gill net catch (18 net-nights) of kokanee was 433 with total lengths that ranged from 54 to 537 mm. The North- and South-Idaho trawls sampled 194 and 115 kokanee, respectively, with lengths that ranged from 30 to 229 mm. The mean gill net catch rate was 23 fish/net-night (SD = 14). Catch rates for stock-, preferred-, quality-, and memorable-sized kokanee were 20, 5, 5, and 2. The two trawls generated different kokanee abundance estimates, both of which included only age-0 and age-1 fish. The north-Idaho trawl estimated approximately 2.3 million kokanee in Anderson Ranch Reservoir. The South-Idaho trawl produced a lower estimate of approximately 1.6 million kokanee; however, both estimates were similar to the average estimate (2003-2014) of age-0 and age-1 kokanee. No valid trawl estimates could be made for kokanee older than age-1. Comparison of the catch among the three sampling methods used to survey the kokanee fishery demonstrate size-related bias. Trawls were ineffective at sampling kokanee greater than 220 mm, whereas gill nets sampled nearly the entire length distribution within the population. Given the results of this year's study, we recommend discontinuing use of the trawl and instead sampling this fishery with gill nets and a check station.

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Introduction

A general description of Anderson Ranch Reservoir and its fisheries is available in the preceding chapter (p. 3). The objective of this study was to estimate mean angler catch, harvest, and fish size harvested during the peak kokanee fishing period. Additionally, creel survey data incorporated with trawl and horizontal gill netting catch data was collected and used to evaluate and monitor population and fisheries status compared to management objectives.

Methods

Angler Survey – Check Station

Indices of angler catch and harvest of kokanee were calculated with information collected at an angler check station. The check station was located at the Curlew Boat Ramp (Figure 2). This location was selected because it represented the highest-use ramp on the reservoir. A total of 16 randomly-selected dates were sampled between June 24 and August 7, 2016. Stations were operated from 0900-1500 h to maximize encounters with anglers who have completed their fishing trips. The station was staffed with one person who contacted all anglers leaving the reservoir. Anglers were asked about the duration of their fishing trip, number of rods, total catch, and total harvest. All harvested kokanee were measured for total length (mm) and weighed (g).

Creel data were summarized by mean trip time, catch, catch rate, harvest, and harvest rate. Mean catch and harvest rate, $\widehat{R_1}$, was estimated using the ratio of means (ROM), where trip interviews were considered complete:

$$\widehat{R_1} = \frac{\frac{\sum_{i=1}^{n} c_i}{n}}{\frac{\sum_{i=1}^{n} e_i}{n}}$$

where $\hat{R}$ is the mean catch or harvest rate in fish/angler hour, c_i is the number of fish caught during the trip, and e_i is the length of the trip in hours (equation $\widehat{R_1}$ from Pollock et al 1994). An estimator of variance of R_1 is

$$\hat{v}(\widehat{R_1}) = \frac{\frac{1-f_d}{(\bar{h}_d)^2 t_d}}{\frac{\sum_{i=1}^{td}\left(c_{d,i} - R_d h_{d,i}\right)^2}{t_d - 1}}$$

Where $\bar{h}_d$ is the average of $h_{d,i}$, f_d is the sampling proportion t_d/T_d and T_d is the total number of angler trips fished and t_d is the number of daily trips (Zhenming and Clapp 2013). The finite population correction $1 - f_d$ (or $1 - \frac{t_d}{T_d}$) was set to 1 in our calculation because T_d is unknown (Rasmussen et al. 1998).

With angler permission, kokanee were processed on location to determine sex, maturity (mature vs. immature), fecundity (eggs/female), and to collect otoliths for aging purposes. Fecundity was estimated by counting eggs within a weighed subsample and expanding that value to the total egg weight (eggs/fish). Excised otoliths were later sectioned and aged in the lab (Summerfelt and Hall 1987). Maturity was visually determined and binomial logit regression was used to evaluate kokanee length at maturity (SAS© software). Fish age data were summarized as mean length at age and fecundity was reported as mean egg/female and egg/g.

Kokanee monitoring

The kokanee population was sampled using three different methods including two trawl nets of differing dimensions (herein referred to as North- and South-Idaho trawls) and horizontal gill nets. The kokanee sampling locations are listed in Appendix A.

This sampling effort was part of a University of Idaho graduate research project comparing two IDFG trawls and their sampling efficiencies. Those results will be published independently; however, the trawl abundance estimates and catch characteristics of each sampling method will be reported here.

All sampling was conducted at night within five days of the new moon. The trawls were fished on June 30, 2016 starting approximately 1 h after sunset. Gill netting occurred during two consecutive nights starting on July 2, 2016.

Both trawl nets were pulled at six systematically-chosen locations (Appendix A). The North-Idaho trawl net is 10.5-m deep with a 3.0- X 2.2-m (area = 4.32 m^2) mouth. The South-Idaho trawl was slightly smaller and measures 11.9-m deep with a 2.4- X 1.8-m (area = 6.6 m^2) mouth. The graduated mesh-size was similar for both nets with body bar-mesh sizes of 32, 25, 19, and 13 mm decreasing from mouth to cod end (6-mm mesh). Both trawls were towed by a 7.3-m boat at 1.6 m/s. Netting started just below the identified kokanee layer and progressed in an oblique-stepwise pattern until the kokanee layer had been completely sampled (Rieman 1992). Step-height was determined by the trawl-mouth dimensions, which was either 2.4 or 3.0 m. Trawls were pulled at an average speed of 1.6 m/s with each step being fished for 3 minutes. Sampled fish were identified, counted (# fish), measured (TL mm), and weighed (g). Trawl-generated kokanee abundance estimates (by year class) were made using an IDFG-produced EXCEL© template that extrapolates kokanee density of the sampled water volume to the entire reservoir. Results are presented as age-specific density (fish/ha), biomass (kg), and standing crop (kg/ha). Kokanee age was determined using the trawl catch (10-mm length increments) to assign age-0 and age-1 year classes and from otoliths collected during the angler survey (described above).

Horizontally-oriented gill nets were set at three systematically chosen locations (Appendix A). Three gill nets were set at dusk at each location for a total effort of 18 net-nights. Horizontal gill nets were 48.8 m-long and 6.0 m-deep with 16 randomly positioned 3 m-long panels of 12.7-, 19.0-, 25.4-, 38.1-, 50.8-, 76.2-, and 101.6-mm stretch mesh (Appendix B). Nets were suspended horizontally within the kokanee layer with one net positioned near the bottom of the layer, one in the middle, and one near the top of the layer. Sampled fish were identified, counted (# fish), measured (TL mm), and weighed (g). Data were analyzed in EXCEL© and summarized as the average catch rate (fish/gill net) and average catch rate by kokanee stock structure (Hyatt 2000).

Results

Angler Survey – Check Station

In all, 221 anglers were interviewed that fished for a combined total of 1,121 h. Their combined catch and harvest was 288 and 263, respectively. Angler effort, catch, and harvest were highest in early July (Table 2). Trip time averaged 5.1 h (SD = 2.0) and ranged from 1 to 10 h. Kokanee catch ranged from 0 to 12 and averaged 1.3 (SD = 2.4). Catch rate ranged from

0.0 to 5.5 fish/h with an average of 0.3 fish/h (SD = 0.6). Harvest was very similar ranging from 0 to 11 with an average of 1.2 (SD = 2.2). Harvest rate ranged from 0 to 5.5 fish/h with an average of 0.3 fish/h (SD = 0.5).

Most kokanee harvested by anglers were measured (237 of 263). The remaining 26 harvested fish were only counted. Harvested kokanee ranged from 230 to 603 mm and averaged 416 mm (SD = 48; Figure 3).

A subsample of measured kokanee was processed to collect otoliths for age analysis and to determine maturity and fecundity (n = 167). Mean length for age-2, age-3, and age-4 kokanee were 382 (SD = 31), 427 (SD = 40), and 467 mm (SD = 28), respectively (Figure 4). Length was not predictive of maturity status for either males (n = 87, r^2 = 0.02; Wald = 2.08) or females (n = 40, r^2 = 0.03; Wald = 1.18); therefore, we could not statistically determine age or size at 50% maturity. Fecundity average 566 eggs (SD = 256) or 24 egg/g (SD = 5).

Kokanee monitoring

The kokanee population was sampled with 18 overnight, gill-net sets and 12 trawl tows. Trawl sample characteristics and locations are listed in Table 3 and Appendix A. In all instances, kokanee was the most-commonly sampled species. In addition, landlocked Chinook Salmon *Oncorhynchus tshawytscha*, Yellow Perch *Perca flavescens*, Largemouth Bass *Micropterus salmoides*, Northern Pikeminnow *Ptychocheilus oregonensis*, Rainbow Trout *Oncorhynchus mykiss*, and Largescale Sucker *Catastomus macrocheilus* were sampled with gill nets. The combined gill-net catch of kokanee was 433 (Table 5) with total lengths that ranged from 54 to 537 mm. The North- and South-Idaho trawls sampled 194 and 115 kokanee, respectively, with lengths that ranged from 30 to 229 mm in both samples. One larger kokanee (405 mm) was sampled with the South-Idaho trawl (Figure 3). The mean gill-net catch rate was 23 fish/net-night (SD = 14). Catch rates for stock-, quality-, preferred-, memorable, and trophy-sized kokanee were 20, (SD = 14), 5 (SD = 5), 3 (SD = 3), 2 (SD = 2) and <1 (SD < 1; Figure 5), respectively.

Kokanee abundance estimates calculated from the North-Idaho trawl were approximately 35% higher than for the South-Idaho trawl, both of which included only age-0 and age-1 fish. The North-Idaho trawl estimated approximately 2.3 million kokanee in Anderson Ranch Reservoir (Table 6). The South-Idaho trawl produced a lower estimate of approximately 1.6 million; however, both estimates were similar to the 14-year average estimate (2003-2016) of age-0 and age-1 kokanee (Table 6). No estimates could be made for kokanee older than age-1 due to gear avoidance.

Discussion

Angler Survey – Check Station

Based on the 2016 check station results, management objectives are only partially being met. The mean catch rate of 0.3 fish/h was less than the target of 1.0 fish/h. This is the second year of check station monitoring where mean catch rates were less than objective. In 2015, 100 anglers were surveyed resulting in the same catch rate (0.3 fish/h, SD = 0.1; Stanton and Megargle, *in press*). The length of harvested kokanee exceeded objective in 2016 with an average length of 416 mm, which exceeds the 305-366 mm target. These observations of relatively low catch rates and large sizes are likely influenced by several factors.

Low adult densities in 2016 may be a result of poor natural recruitment, harvest, and increased avian and fish predation. The Elk Creek Fire occurred in the SFBR drainage in August 2013 and its aftereffects are thought to have reduced kokanee recruitment since. The fire resulted in minor debris flows in 2013 and more severe debris flows in August 2014 and 2015. The timing of the debris flows coincided with kokanee spawning within the SFBR, which is thought to provide the majority of the reservoir's kokanee recruitment. Substantial quantities of sediment were deposited throughout the river likely reducing the quality of kokanee spawning habitat temporarily. Minimal numbers of spawning kokanee were observed during informal surveys of the SFBR after these debris flows suggesting production and recruitment were negatively affected or low. The trawl abundance estimates made in 2014 recorded one of the lowest abundance estimates for age-0 kokanee since 2003 suggesting the minor debris flows of 2013 had substantial impacts to kokanee recruitment. In addition, landlocked Fall Chinook Salmon were stocked in the reservoir in 2013, and are thought to consume young kokanee. In addition, pelican numbers have increased substantially during the past 3-5 years. The avian predators have focused their feeding at the mouth of the SFBR where kokanee stage prior to spawning. Kokanee are most vulnerable to predation in low water years when they enter the river through a wide and shallow sediment delta. The magnitude of these sources of mortality and variability are not clearly understood.

In order to hasten population increases and meet management objectives, fingerling kokanee were stocked during 2016. In addition, IDFG implemented a hazing program at the mouth of the South Fork Boise River to reduce avian predation on the low numbers of adult kokanee. Annual stocking and avian predator hazing should continue until it is determined that natural recruitment has increased to levels sufficient to maintain this fishery.

Low catch rates in 2016 were likely due to the low adult densities at the time of the angler survey. The combined effects of poor recruitment in 2013-14 and reportedly increased angling effort in 2015-16 on those year classes resulted in low catch rates in 2015 and 2016. In 2016, anglers harvested kokanee between 230-603 mm. Kokanee growth is density dependent and the large fish size is indicative of a low density (Reiman 1992). Furthermore, the 2014 trawl abundance estimate showed relatively low numbers of age-0 and age-1 kokanee that would translate to a relatively low density of age-2 and age-3 fish in 2016. These size classes were poorly represented in the June 2016 gill net samples that were completed around the same time the check station was run. Angler harvest prior to the angler check station may have reduced the number of larger kokanee in the fishery and thus affected catch rates determined with the 2016 check station.

The timing and duration of the check stations may not be producing estimates that reflect the season-long angling experience. The check station was originally scheduled in 2015 to coincide with what was thought to be the typical peak in angling effort (Jeff Day, Senior Conservation Officer, IDFG, personal communication). Lower adult kokanee densities have resulted in unusually large kokanee in the fishery, and the angler response to this opportunity is thought to have increased effort including to earlier in the season (Jeff Day, Senior Conservation Officer, IDFG, personal communication). Conservation officer reports indicated the April-June in 2015 harvest was substantial and angler success was better prior to running the check station. To adapt to these changes, the 2016 check station sampling period was initiated three weeks earlier and its duration was extended by 3 weeks. However, staff operating the check station in 2016 reported declining angler effort and harvest towards the end of the survey suggesting the check station needs to be moved to an earlier time period. We should consider realigning the check station to the observed 2016 fishing effort.

Kokanee monitoring

Monitoring trends in kokanee abundance is difficult. Based on length-frequency data, it appears trawls only sampled age-0 and age-1 kokanee. Assuming trawl-derived estimates are accurate, a large number of those age classes are present compared to previous years. Approximately 200,000 kokanee were stocked in ARR just prior to the trawl sampling.

Accounting for the hatchery supplementation, the reservoir's kokanee population contains approximately 900,000 age-1 kokanee. Very few kokanee were observed spawning in the SFBR mainstem which means kokanee may have spawned in a SFBR tributary or a separate drainage altogether. Determining the source for this unexpected recruitment would be prudent and help improve the understanding of this fish population and inform management of this fishery.

Comparison of the catch among the three sampling methods used to survey the kokanee population demonstrate bias. Findings suggest that trawls are ineffective at representationally sampling kokanee over 200 mm; whereas gill nets sampled nearly the entire length distribution present. Densities, standing crops, and biomass estimates derived from trawls for age-0 and age-1 kokanee were similar to the long-term average. Trawl-derived estimates for larger-sized kokanee are questionable. Furthermore, trawl estimates produced cohort abundant estimates that conflicted among years. For example, in 2010, trawl-generated estimates for age-2 kokanee (~137,000) were nearly twice the estimate for age-1 kokanee (~57,000) the year prior making mortality estimates problematic. Trawls were used in large part due to the value of the quantitative estimates to inform hatchery supplementation and escapement management efforts. Additionally, trawl data were used to provide fishing forecasts for anglers. Given the results of this year's study, we recommend discontinuing trawl-based monitoring and to continue gill nets and check station surveys. Future lack of age-specific abundance estimates is unfortunate; however, index data from nets will be sufficient to monitor and manage this fishery.

Recommendations

1. Stock early-run kokanee in Anderson Ranch Reservoir when needed.
2. Continue to employ an annual angler check station, to determine if the fishery is meeting management objectives of 1 fish/h of kokanee ≥305 mm.
3. Standardize annual sampling efforts to include horizontal gill nets, in an effort to sample all size classes of kokanee present in the fishery.
4. Assess plausible abiotic and biotic factors that may affect fishery and populations statuses.
5. Evaluate options to determine source-specific natural recruitment and their relative contribution to kokanee recruitment in ARR.
6. Continue to employ an annual angler check station, to determine if the fishery is meeting set management objectives of 1 fish/h of kokanee ≥305 mm.

BRUNEAU DUNES

Abstract

Dunes Lake was chemically renovated on October 27, 2016 in an effort to eradicate Common Carp *Cyprinus carpio*. Synpren© Fish Toxicant (5% rotenone; EPA Reg #655-422) was applied with two methods, two fixed-wing aircraft and one drip station. Drip station treatment was initiated at approximately 1000 h and completed by 1430 h that same day. Aerial application ran from 1100 to 1215 h. A total of 1,825 liters of Synpren was applied to treat a volume of 44.53 ha/m in Dunes Lake. The lake was treated at a label-prescribed rate of 4 ppm described as adequate for carp in an organic-rich environment. Prior to the rotenone application, 120 Largemouth Bass *Micropterus salmoides* and 17 Bluegill *Lepomis macrochirus* were collected using electrofishing techniques; and released into the adjacent Bruneau Pond. Treatment success was determined using sentinel cages containing Rainbow Trout *Oncorhynchus mykiss*. Results indicated the application reached sufficient concentration to be effective.

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Introduction

The Bruneau Sand Dunes are located within the Bruneau Dunes State Park approximately 25 km south of Mountain Home, Idaho. Two waters referred to as Bruneau Pond and the larger Dunes Lake are located at the base of the sand dunes. These waters were developed or became more prominent in the early 1950s after ground-water levels increased from nearby row and flood irrigation of agricultural lands. However, recent transition to center-pivot sprinkler irrigation resulted in a lowering of ground-water levels by 1.3 m. Lower ground-water levels desiccated most ponds, but Bruneau Pond and Dunes Lake remain. Anticipating future desiccation, a pump was installed to bring Snake River water into the Bruneau Pond in 1987. Snake River water has been pumped usually in the spring and fall since the pump installation was completed. Water pumped into Bruneau Pond flows through the head gate of a dyke separating Dunes Lake. Bruneau Pond is approximately 12 ha in surface area, and Dunes Lake is approximately 32 ha in surface area at current water management levels (Partridge and Warren 1995).

The fishery in both waters is managed for Largemouth Bass *Micropterus salmoides* and Bluegill *Lepomis macrochirus.* There is currently a two fish, 20-inch (508 mm) minimum length limit for Largemouth Bass on both waters. There are no size or bag limit restrictions for Bluegill. Over time, Common Carp have become established in Dunes Lakes and are thought to have increased in abundance. This has caused the Largemouth Bass and Bluegill populations to decline resulting in reduced angling opportunity and quality. Due to the popularity of the Bruneau Dunes State Park Campground and interest in this fishery, staff decided to chemically eradicate carp from Dunes Lake. Therefore, the objective of this effort was to improve the resident warm water fishery by eliminating interspecific competition associated with the Common Carp population in Dunes Lake. The lake was chemically renovated (rotenone) to achieve this objective.

Methods

Prior to the application of rotenone, Largemouth Bass and Bluegill in Dunes Lake were salvaged using electrofishing techniques. The catch was transported and released in the Bruneau Pond.

Dunes Lake was drafted to a minimum pool in an effort to maximize the efficiency of the treatment and to reduce the amount of chemical needed. Additionally, drafting isolated the remaining fish from complex near-shore cover and concentrated them in one large shallow pool, potentially increasing the treatment efficacy. We used the minimum pool volume to determine the quantity of rotenone product needed for an effective treatment. The pool volume was estimated using the product of the estimated surface area [mean length (m) X mean width (m)] and mean depth (m) of the remaining pool. We used a range finder to determine linear distances and a hand-held depth finder to determine depths (Appendix B).

The Department followed rotenone application guidelines as outlined in the Planning and Standard Operating Procedures Manual for the Use of Rotenone for Fish Management (Finlayson et al. 2000). Synpren© Fish Toxicant label (5% rotenone; EPA Reg #655-422) was the product selected for the treatment. We adhered to label-prescribed mixing and application requirements. The pond was treated at a label prescribed rate of 4 ppm described for use for carp in an organic rich environment. Fish toxicant was applied with two methods of application, two, fixed-wing aircraft and one drip station. Valley Air Inc. (VAI) completed the treatment with IDFG oversight. The treatment lead was Scott Stanton (ISDA Applicator License 50881). VAI applied 1,825 L of Synpren Fish Toxicant to 361 AF of water (1 gal treats 0.75 AF). The product was diluted prior to loading the airplanes at a 3:1 (water:product) ratio. The drip station applied 1.5 L of product over 4 h to treat a flow of 1 cfs.

Sentinel cages were used to determine treatment efficiency. Sentinel cages contained eight to ten Rainbow Trout and were deployed prior to the chemical application (n = 3). Cages were checked to determine if concentrations were lethal. An additional cage was placed in the Bruneau Pond to determine if rotenone was being over-sprayed by the aircraft.

Treated water was left to detoxify naturally. Sentinel cages were used to determine when the rotenone oxidized sufficiently and concentrations were no longer lethal. Cages containing live fish were placed in three locations starting four days after treatment and evaluated after 24 h. Testing continued until fish survived at least 24h.

Results

Prior to the treatment, approximately 120 Largemouth Bass and 17 Bluegill were captured in Dunes Lake and transported and released into Bruneau Pond.

The pre-treatment drawdown of Dunes Lake was a successful approach toward maximizing treatment efficiency. The remaining pool was completely isolated from shoreline vegetation. Treatment volume was substantially reduced and fish access to complex habitat was essentially eliminated.

Renovation of the Dunes Lake was completed on October 27, 2016. Drip station treatment was initiated at approximately 1000 h and completed by 1430 h. Aerial application began at 1100 h and was completed by 1215 h. VAI applied 1,825 L of Synpren Fish Toxicant to treat 44.53 ha/m of water. The product was diluted prior to loading the airplanes at a 3:1 (water: product) ratio. The drip station applied 1.5 L of product over 4 h to treat a flow of 1 cfs (Table 11). Lethal concentrations were confirmed within 5 h from initial application. Detoxification was confirmed approximately 7 d after treatment when trout in sentinel cages survived at least 24 h.

Discussion

All fish in sentinel cages perished after treatment, and no live fish, including carp, were observed or sampled post-treatment. Carcasses were collected from approximately 200 meters of shoreline on the west side of the pond and removed to minimize public impact in a high-use area of the State Park. Approximately 3,000 kg of carcasses were hauled to a local rendering plant.

This was the first fixed-wing aircraft rotenone application in the Magic Valley Region. Logistically speaking, this is a much easier and safer application method as less raw product was handled by staff. Furthermore, mixing, washout, loading, and rinse stations needs were reduced. The aerial applicators were responsible for handling and mixing raw product at their facility and loading station. They were also responsible for rinsing and disposal of containers. Aerial application is also a much more efficient way of distributing product more evenly and quickly across a water.

Contracted aircraft application was only marginally more expensive than application by department staff. Fixed-wing aircraft rotenone application cost was $4,500. If the staff would have applied product with boats, cost would have approximated $3,810 (Table 12). Total volume of water treated in the fishery was 44.53 ha/m. For Dunes Lake, Application by fixed-wing aircraft cost $101/ha/m, whereas treating the fishery by boat and with staff would have cost an estimated $85/ha/m.

There are many variables associated with treatment cost and assessing cost efficiency for other waters. Product transport and ferrying costs will vary based on location of the treatment site relative to distance from aircraft hangers and chemical storage areas. Treatment cost will also depend on water size and needed chemical concentration. The marginally higher cost for aircraft application at Dunes Lake was deemed acceptable due to the reduction in staff time needed to complete the project.

Recommendations

1. Use baited hoop-nets and electrofishing in spring 2017 to further assess treatment efficacy.
2. If deemed successful, reintroduce Bluegill in 2017 and Largemouth Bass in 2018. Transplant prior to spawn.

MAGIC RESERVOIR

Abstract

The Smallmouth Bass *Micropterus dolomieu* population at Magic Reservoir was sampled utilizing boat electrofishing methods in 2016 as part of long-term trend monitoring efforts. A total of 89 bass were collected. Using 10, 15-minute units of electrofishing, Catch Per Unit Effort (CPUE) equaled of 9 ± 3 (80% C.I.). Mean total length (TL) and relative weight (*Wr*) were 160 ± 7 mm and 105 (*n* = 43, SD = 14), respectively. The Smallmouth Bass PSD was 22 with a RSD (S-Q) of 77. A subsample of Smallmouth Bass were aged (*n* = 65). We documented 5 age classes. Maximum aged fish in the sample was 5 years old with a length of 381 mm. Annual mortality (ages 1-5) was 64%.

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Introduction

Magic Reservoir is located approximately 48 km north of Shoshone, Idaho, within the Big Wood River drainage. The earthen dam was constructed in 1909, and enhanced in 1917 to a maximum height of 34.4 m. The reservoir is managed to provide irrigation, downstream flood control, hydroelectric power production, and recreation. The reservoir is approximately 1,529 ha when full, but is subject to extreme drawdown associated with irrigation demand. During high water years, water passes over a spillway into the lower Big Wood River drainage.

Magic Reservoir possesses self-sustaining populations of Brown Trout *Salmo trutta*, Yellow Perch *Perca flavescens*, and Smallmouth Bass *Micropterus dolomieu*. In addition, Rainbow Trout *Oncorhynchus mykiss* are stocked as fingerlings and catchables. Also, Brown Trout and Rainbow Trout migrate out of the reservoir and spawn in the Big Wood River. The contribution of wild recruits to this fishery is not well understood.

Smallmouth Bass in Magic Reservoir are managed as a regional exception with a 6-bass daily bag limit and no minimum size limit. This relatively liberal harvest regulation remains in place to encourage bass harvest as trout and perch management are priorities and because bass growth is very slow here due to cold water temperatures. Protective bass regulations may be counterproductive in a fishery mainly supported with fingerling trout stocking. Additionally, expanded bass populations may limit perch recruitment particularly during drought periods when cover is limited. Our objectives were to measure abundance (CPUE), stock structure, and general condition (*Wr*) of the bass population in Magic Reservoir. Results will be used to compare trends within the fishery and among other regional bass fisheries.

Methods

Smallmouth Bass were sampled at Magic Reservoir with nighttime boat electrofishing; using a Midwest Lake Electrofishing System (MLES) Infinity unit set at 24% duty cycle and approximately 2,200-2,800 watts of pulsed DC power. Current was generated by a 4000-watt Honda generator. Detailed descriptions of the electrofishing unit are provided in Appendix B. One sampling unit (15 minutes of power-on) was utilized at randomly selected sample locations. Catch results were reported as relative abundance (expressed as mean catch/unit effort), stock structure, fish condition (*Wr*), fish growth (length-at age), and fish survival (catch curve). Smallmouth Bass sampling was conducted in the spring with water temperatures between 15^{o} C and 24^{o} C when bass are known to spawn (Heidinger 1975).

All Smallmouth Bass sampled were measured for total length (TL, mm) and weighed (g). Efforts were made to collect five fish from 1-cm length bins from the full range of sizes. Within this subsampled, otoliths were removed and prepared for laboratory aging. Ages were estimated by breaking the otolith centrally, then burning or browning the broken edge with an alcohol burner, and viewing the otolith with a dissecting microscope at 30 – 40X. Otoliths were coated with mineral oil to improve viewing clarity (Devries 1996). Mean length-at-age was calculated from this subsample of fish. Fish growth was described using the mean length-at-age summary in FAST© software package (Fisheries Analysis and Simulation Tools, Version 2.1©).

Stock structure and condition indices were generated using the FAST© software package. Proportional stock density (PSD) was calculated to index the Smallmouth Bass population stock structure (Anderson and Neuman 1996). Relative weights (W_r) were calculated using EXCEL© software and are reported as the mean W_r. Furthermore, mortality and survival rates were estimated to better understand population dynamics. Annual mortality and survival rates were estimated using a catch curve (Van Den Avyle 1993). Catch curves were generated using the FAST© software package.

Results

Smallmouth Bass sampling at Magic Reservoir occurred June 7-8, 2016. A total of 89 bass were collected for a catch per unit effort (CPUE) of 9 ± 3 (80% C.I.) using 10, 15-minute units of electrofishing. Mean length and weight (g) was 160 ± 7 mm and 105 (n = 43, SD = 14), respectively (Figure 8). We documented five age classes present in the sample (n = 65). The maximum age was 5 (mean length = 381 mm, Figure 9).

The Smallmouth Bass PSD was 22 with a RSD (S-Q) of 77 ± 14 (Table 13). Mean relative weights for each size class of bass were 108, 104, 85, 94, 0 and 0 % for sub-stock, stock, quality, preferred, memorable, and trophy-sized bass. Annual mortality (ages 2 -5) was 64% (R^2 = 0.97; F value = 64.35).

Discussion

Comparisons between the 2012 and 2016 surveys show few major changes to bass population parameters. Mean length at age-5 in 2012 and 2016 were similar to the statewide average of 300 mm (Dillon 1992); however growth rates in 2016 were higher overall compared to bass sampled during 2012. There were subtle shifts in PSD, RSD(S-Q), CPUE, and W_r between the 2012 and 2016 surveys.

The larger discrepancy in the maximum age of bass collected might be the result of a sampling bias against larger fish related to the survey timing of the 2012 and 2016. Survey timing was set to maximum size and age class diversity. Focusing the survey during the spawning period was deliberate to target larger-sized bass efficiently when they use shallow spawning habitat and more vulnerable to electrofishing. Results from the past surveys suggest the sampling may not be consistently occurring during peak spawn. More age classes were sampled in 2012 (eight year classes) than in 2016 (five year classes). Few ripe bass were observed in the catch from 2012 and 2016; however, more ripe fish were surveyed in 2012. Detection of ripe fish in 2012 coincided with the collection of older fish and a greater number of cohorts. The maximum bass age sampled in 2012 was 11 years old verses the other two surveys where the maximum age fish collected was 4 or 5 years. We conclude that the Smallmouth Bass population in Magic Reservoir is relatively small, based on low CPUE, and slow growing. In the future, population trends should be tracked with consistently-timed sampling efforts to ensure consistent characterization of population parameters.

Recommendations

1. Initiate future sampling efforts based on date and water temperature to ensure as much consistency as possible.

2. Continue to monitor growth, mortality, and exploitation to determine whether management as an exception is warranted.

OAKLEY RESERVOIR

Abstract

The Walleye *Sander vitreus* population in Oakley Reservoir was assessed using a Standard Fall Walleye Index Netting (FWIN) survey on October 5 and 6, 2016. An effort of seven net-nights yielded a total catch of 244 Walleye. Catch per unit effort was 35 $\pm$ 15 (95% CI). The PSD of the catch was 7 $\pm$ 3 (95% CI). Stock density of the catch was 78, 4, 0, 0, and 0 % for RSD-P, RSD-M, and RSD-T, respectively. A subsample of the catch was aged (n = 195). Eleven age classes were present and ranged from 2 to 13 years. Mean relative weights for each Walleye stock size were 81, 89, 100, 0, and 0 % for stock-, quality-, preferred-, memorable-, and trophy-sized Walleye, respectively. Relative weights of female and male Walleye were 81. Visceral fat indices were 2.3 for males and 1.8 for females. Gonadal somatic indices for males and females were 2.9 and 1.87, respectively. Maturity rates were for males and females were 43% and 4%, respectively. Annual mortality of Walleye (sexes combined) based on weighted catch curve analysis was 13%. The overall FWIN ranking was 1.75 on a scale of 1-3, which classifies the population as “unhealthy and unstable” to “stressed and unstable”.

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Introduction

Oakley Reservoir is a 548-ha irrigation impoundment located in the lower reaches of the Goose Creek and Trapper Creek drainages. The reservoir is located about 10 km south of the town of Oakley, Idaho in Cassia County. As a whole, the Goose Creek watershed is very arid. Much of the basin receives less than 25 cm of precipitation annually, while the mountainous areas receive up to 76 cm. Rainfall in the mountains provides most of the perennial flow into Oakley Reservoir.

Oakley Reservoir is managed as a mixed-species fishery that includes Rainbow Trout *Oncorhynchus mykiss*, Yellow Perch *Perca flavescens,* and Walleye *Sander vitreus*. Other species present include sculpin *Cottus* sp., Largescale Sucker *Catastomus macrocheilus*, and Spottail Shiner *Notropis hudsonius*. Spottail Shiner was introduced in 1989 to provide additional Walleye forage. Oakley Reservoir is one of only three waters in Idaho managed to provider a Walleye fishery. As such, the Walleye population at Oakley Reservoir is monitored at 3-5 year intervals. The objective of this survey was to resample Oakley Reservoir and compare FWIN results to the established average baseline set by FWIN sampling in 2007-2009.

Methods

Standard Fall Walleye Index Netting (FWIN, Morgan 2002) protocol described in the Manual of Instructions – Fall Walleye Index Netting guided sampling efforts on Oakley Reservoir in 2016. Based on a maximum reservoir surface area, target sample size was 16 gill-net nights. A biological threshold of 300 Walleye was set prior to sampling. Sampling was discontinued when either sample size or biological threshold were met. Gill nets were eight panel monofilament nets 1.8-m deep, 61.0-m long, with 7.6-m panels measuring 25-mm, 38-mm, 51-mm, 64-mm, 76-mm, 102-mm, 127-mm, and 152-mm stretched mesh. Net locations were randomly selected and are listed in Appendix A. Net sets were equally split between two depth strata including 2 – 5 m and 5 – 15 m. All nets were placed perpendicular to the shoreline. Netting was conducted when water temperatures were between 10 and 15 °C.

All sampled Walleye were measured (TL, mm) and weighed (g). Otoliths were collected from all sampled walleye. Otoliths were prepared for age estimation by breaking centrally. Growth patterns were described by estimating mean length at age by sex.

Mortality and survival were estimated to evaluate the effects and interaction of exploitation and natural limiting factors on the fishery. Walleye annual mortality and survival were estimated using a catch curve (Van Den Avyle 1993). Catch Curves were generated with the FAST software program.

Condition indices were generated from sampled walleye to describe the general health of the population. Visceral fat was removed and weighed to measure condition and to calculate a visceral fat index. The visceral fat index was calculated as the ratio of visceral fat weight to total body weight and described as a percentage. Gonads were removed and weighed to estimate a gonadal somatic index value for each fish. The gonadal somatic index value was calculated as ratio of gonad weight to body weight and described as a percentage. Relative weights were calculated and summarized by size groups labeled as stock, quality, preferred, trophy, and memorable as defined in FAST (Anderson and Neumann 1996).

Sexual maturity status was determined for all Walleye (Duffy et al. 2000). We examined the relationship and length and age at 50% maturity using logistic regression (Quinn and Deriso 1999). A female diversity index value was estimated based on the Shannon diversity index to describe the diversity of the age structure of mature females (Gangl and Pereira 2003). The female diversity index has been shown to be sensitive to exploitation and may provide indications of overexploitation (Gangl and Pereira 2003). Ovaries were collected from mature females for estimation of fecundity. Fecundity estimates were generated for a sub-sample of eggs, weighed and counted from each fish. Fecundity estimates will be used in future population modeling.

Benchmarks were used to classify the relative condition or status of the Walleye population. Classification parameters included: CPUE for Walleye ≥ 450 mm, number of age classes present, maximum age, and female diversity index. Parameters represented measures of abundance, growth, age structure, and recruitment potential. Parameters were scored from one to three, three reflecting a healthy stable population. The average score among all parameters reflected the overall health of the population.

Results

A total of 244 Walleye were sampled using seven net-nights, resulting in a CPUE of 35 ± 15 fish/net-night (95% CI). Total length of sampled Walleye ranged from 144 to 541 mm (Figure 12). The PSD of the catch was 7 ± 3 (95% CI). Stock density of the catch was 78, 4, 0, 0 and 0 % for RSD-P, RSD-M, and RSD-T, respectively (Figure 13). A subsample of the catch was aged (*n* = 195). Eleven age classes were present, and ages ranged from 2 to 13 years (Figures 14-15). Weights ranged from 22 to 1,845 g. Mean relative weights for each Walleye stock size were 81, 89, 100, 0, and 0 % for stock-, quality-, preferred-, memorable-, and trophy-sized Walleye, respectively. Relative weights of female and male Walleye were 81% (Figure 16).

Visceral fat indices for males and females were 2.3 and 1.8, respectively. Walleye had a gonadal somatic index for males and females were 2.9 and 1.87, respectively. Forty-three and four percent of the males and females were mature, respectively. Based on weighted catch curve analysis and for the sexes combined, annual mortality of Walleye was 13% (Figure 17).

The FWIN benchmark ranking was 1.75 on a scale of 1-3; which classifies this fishery as “unhealthy and unstable” (Tables 14-15).

Discussion

The most notable changes in 2016 when compared to the 2007-2009 baseline was an overall decreased rating in population health and stability, an increased CPUE, a drastic decline in Walleye ≥ 450 mm, absence of preferred, memorable and trophy sizes, a substantial decrease in the maximum age of walleye, as well as a noticeable decrease in VFI and GSI indices. Based on catch and length-at-age estimates, the majority of the population is comprised of age 2-6 Walleye and is dominated by the age 3-4 cohorts. Walleye were not stocked during 2012-15 suggesting that natural recruitment has been annual recently. In comparison to the number of age-1 Walleye caught in the 2007-2009 surveys, relatively few <200 mm were collected in 2016 indicating relatively poor recruitment in 2015. However, this notion should considered with caution as sample sizes for this portion of the Walleye population are small and Walleye are not fully recruited to the gear at this length.

Growth rates peak around age-6, which differed from the past surveys and potentially indicates a forage-limited situation for younger Walleye. However, growth recovers slightly for the older age classes suggesting available forage in Oakley may exceed the gape size of younger Walleye. A substantial decline in GSI and VSI indices provides further evidence of a potential forage limitations. The relatively high CPUE implies there was good recruitment 3-4 years previous to 2016, when no stocking occurred, with those progeny growing at similar rates as seen in the past survey.

The CPUE documented in the 2007-2009 and 2016 surveys are generally higher than the CPUE recorded in other fisheries. Average CPUE calculated from FWIN survey of Washington State lakes and reservoirs was 19 (WDFW 2005). In contrast, CPUE from FWIN surveys conducted across the province of Ontario and Alberta (Carruthers et.al 2008, 2011) ranged from 2.8 to 10.7 fish per net. Recent Walleye surveys in five Washington State lakes and reservoirs showed CPUEs ranging from 4 to 32 fish/net-night (Bolding 2008, Schmuck 2011). Based on these comparisons, the Walleye population in Oakley Reservoir is highly abundant which has led to reduced prey populations, poor Walleye condition, and slow growth rates.

Management options to improve habitat for Walleye and their forage in Oakley Reservoir are limited. The reservoir primary purpose is to supply water for crop irrigation. Changes in snow pack and subsequent runoff directly affect the quantity and quality of habitat for Walleye and their forage. Drastic vertical changes in pool elevation can restrict access to critical cover and preferred spawning habitat such as submerged willow *Salix* sp. for Yellow Perch. Habitat quality is dependent upon annual precipitation and water management. Recovery of forage population are unlikely due to highly-abundant Walleye and inconsistent availability of flood vegetation for perch spawning especially during drought cycles. Forage supplementation would likely be ineffective until Walleye populations are reduced and habitat is improved.

In the recent past, IDFG has requested 750,000 Walleye fry to supplement suspected limited natural recruitment in Oakley Reservoir. Ryan et al. (2007) concluded that post-stock fry survival may be variable ranging from 0 to 22% (Ryan et al. 2007). Our analysis seems to contradict this notion. Natural recruitment appears to be consistent as several age classes were present from non-stocking years, including several that appear to be relatively strong based on catch curve residuals. Future stocking numbers and frequency need to be reduced especially until Walleye population abundance declines and until forage populations increase.

Collectively, the changing variables documented in this survey describe a high-density Walleye population potentially limited by forage, exhibiting suppressed growth, and with absence of larger-sized fish once found in the fishery. This description is in agreement with the overall ranking (1.75) that classifies the status of the fishery as “unhealthy and collapsed”, but approaching “stressed and unstable”. The fishery has declined since the 2007-2009 surveys when the status was “healthy and stable”.

Recommendations

1. Preserve the five-year trend sampling rotation. Resample Oakley Reservoir in 2021.
2. Estimate catch rates and angler exploitation to determine if additive mortality is impacting population size structure and abundance.
3. Reduce stocking numbers and frequency until forage populations increase.

SILVER CREEK

Abstract

American White Pelican *Pelecanus erythrorhynchos* was first reported using Silver Creek as a foraging area in 2013. Anecdotal observations indicate that use may be increasing leading to concerns about predation effects on this world-class trout fishery. To reduce foraging efficiency and reduce potential effects, pelicans were actively hazed 48 times during a one-month period in May-June 2016. Three quarters of the hazing events involved small groups of 1-10 pelicans. Six percent of hazing events involved groups of 20 pelicans or more. Soft hazing (e.g. approach by vehicle, yelling, arm movements) was less effective and never resulted in an adequate initial fright response. Use of pyrotechnics generally provided the most effective behavioral responses. Adequate fright responses were common when using pyrotechnics; however, whistler rockets invoked an adequate response in 91% of all contacts compared to 15% using only cracker shells. Although no clear trends were identified, most hazing interactions occurred during crepuscular times. IDFG staff were able to disrupt but not eliminate pelican foraging on Silver Creek. Approximately 30-50 pelicans visited Silver Creek daily, suggesting hazing was not a lasting deterrent to pelican loafing and foraging behavior.

Rainbow *Oncorhynchus mykiss* and Brown Trout *Salma trutta* were sampled on Silver Creek with electrofishing in 2016 as part of the continued trend-monitoring efforts which has been conducted on a three-year rotation. The estimated number of Rainbow Trout in the sample reach (≥ 100 mm) was 575 ± 206 (95% CI), which equated to 416 Rainbow Trout/km. The estimated number of Brown Trout in the sample reach (≥ 100 mm) was 473 ± 132 (95% CI), which equated to 342 Brown Trout/km.

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Introduction

Silver Creek is a tributary to the Little Wood River located in Blaine County, Idaho. Silver Creek originates at the confluence of two main spring creek tributaries, Stalker Creek and Grove Creek on the Nature Conservancy's Silver Creek Preserve. Silver Creek and its tributaries provide a popular destination fishery for Rainbow *Oncorhynchus mykiss* and Brown Trout *Salmo trutta*.

These populations, their habitat, and the fishery, including its tributaries, have been the focus of several studies during the past 10 years including descriptions of Brown Trout and Rainbow Trout movements (Young et al. 1997), fish community structure (Wilkinson 1996), genetic population structure (Williams et al. 2000), and whirling disease presence and prevalence (Spall et al. 1996). Thermal imaging has been used to describe water temperature and assess its effects on salmonid populations. Standard IDFG population monitoring transects and survey protocols were defined in 2004 and monitored at three-year intervals since. The entire Silver Creek drainage has also been the focus of numerous stream restoration or alteration projects in the last 15 years.

Trout populations in Silver Creek are sustained through natural recruitment. The lower reaches of Silver Creek are dominated by Brown Trout. Farther upstream, Rainbow and Brown Trout are more equally represented. Habitat conditions in Silver Creek are generally good for maintaining trout population, though changes in hydrology, excessive sediment loading, and spawning habitat degradation have the potential to degrade habitat and affect populations (Ecosytems Sciences Foundation 2016). The resource is highly valued by the community, which is best illustrated by high angler use and substantial investment in habitat restoration projects by privately-funded local groups and individuals.

Beginning in 2013, IDFG began receiving reports of sightings of large numbers of pelicans at Silver Creek. Prior to 2013, very few sightings were reported with the exceptions of individuals or small groups (1-10 pelicans). Though formal pelican counts or abundance trends are not available, there appears to be an increase in pelican use of Silver Creek as a foraging area. Pelican predation rates on trout in Silver Creek are unknown at this time, though of some concern based on increasing pelican trends statewide and substantial predation effects on The Blackfoot River, a similarly-size river.

The effects of Pelican foraging activities on Silver Creek's wild trout populations remain unknown. No quantitative predation rate has been estimated; however, relatively high pelican abundance and the lack of alternative prey, other than trout, result in some concern, considering the high-profile nature of this fishery. Under such circumstances, IDFG's current American White Pelican Management Plan directs staff to implement management actions to reduce or eliminate avian predation using non-lethal techniques (IDFG 2016). The plan also recommends hazing as the preferred method for deterring pelican foraging behavior on wild fish (IDFG 2016). Therefore, at Silver Creek, we plan to measure pelican behavior (fright response, duration, and foraging behavior) in response to non-lethal hazing efforts. Secondly, we plan to assess trout community by assessing abundance and structure using mark-recapture techniques. Results will be compared to previous sample years (2001, 2004, 2007, 2010, and 2013) to assess trends.

Methods

Pelican Hazing

Hazing began on May 13 and was discontinued on June 10, 2016. Hazing was discontinued shortly after the opening day of the fishing season (Saturday of Memorial Day weekend) to minimize conflict with anglers and because angler presence disrupted pelican use of Silver Creek. Staff hazed six days a week during daylight hours. Hazing efforts occurred on Silver Creek proper and on privately-owned ponds located adjacent to the creek.

Each day, staff completed several reconnaissance surveys using various vantage and access points throughout the defined area to locate foraging and loafing pelicans. Hazing ensued immediately once pelicans were located. Staff were instructed to initiate hazing with "soft" methods and to increase intensity to "hard" hazing methods should the pelicans fail to respond. Soft hazing included voice and arm movements, whereas hard methods included pistol-fired cracker shells and whistler-rockets that exploded near the end of the rockets' flight trajectory.

With each hazing action, staff recorded the time and location of the event (GPS), the number of pelicans, behavior prior to hazing (feeding, loafing, swimming), number of banded pelicans observed, the type of hazing effort (human approach, cracker shell, rocket), bird response (good, mild, poor), post-hazing flight observations (flight distance and direction), and whether the pelicans returned (yes, no).

Staff also recorded observations of pelican activity not directly involved in a hazing event. Staff recorded observations of pelicans that appeared to be passing through the area not stopping on the creek or on adjacent ponds. Observations included the location of the observation (general description), flock size, number of tagged pelicans, the direction of flight, time of day, gross determinations of flight altitude (low, high, gaining altitude), and any other general observations (e.g. wings were locked, looked like they were landing north of Picabo, etc.). Data were summarized by the number of pelicans encountered, number of hazing events and the overall efficiency of the hazing effort.

Trout Survey

During 2016, these populations were sampled at three locations to evaluate trends in abundance and structure. Sampled segments included: lower Stalker Creek; Silver Creek (Cabin Site) and Silver Creek (Martin Bridge; Appendix A). Fish were sampled with an electrofishing unit mounted to a 9' Outcast inflatable canoe. The unit included two mobile anodes connected to 15-m cables, a 5000-W generator (Honda EG500X), a Midwest Lake Electrofishing Systems (MLES) Infinity electrofisher, and a livewell for holding fish. The cathodes consisted of three octopus cable bar that totaled 1.5 m in length and consisted of 15 cable danglers. Oxygen was pumped to the live well (2 L/min) through a 10" fine bubbler air-stone. Pulsed direct current (DC) was produced by the generator and electrofisher. Settings were 24% duty cycle, 60 pulses per second, 300-400 volts, producing 1,000-2,000 W. Fish were sampled on two passes separated by seven days. Sampling was conducted during daylight hours. During the marking run, fish were identified, measured (TL), weighed (g), marked, and released. The upper caudal fin of sampled trout was marked with a 7-mm diameter hole from a standard paper punch. Only fish longer than 100 mm were marked. Fish were released 50 to 100 m upstream from the processing site to reduce the potential of movement out of the site or into areas yet to be electrofished. During the recapture effort, all trout greater than 100 mm were captured and placed in the livewell. Fish were identified, examined for marks and measured for total length (mm).

Estimates of Rainbow and Brown Trout abundance were made using a modified Peterson mark-recapture estimator (Ricker 1975). Estimates were summarized by length in 100-mm bins for fish equal to or greater than 200 mm. A minimum of five recaptures for each length bin was required for estimation. Length groups that did not include a minimum of five fish were then pooled with the next (longer) length bin.

Length-at-age and mean total length were used to characterize stock structure in each reach. Sectioned otolith samples were examined to determine fish age. In transects where a population estimate could not be estimated relative stock densities (RSD – 400) were determined. RSD-400 is calculated as the number of fish ≥ 400 mm divided by the number of fish ≥ 200 mm. Relative weight was calculated and reported as mean relative weight by 100 mm length groups in Fisheries Analysist+ (FA+); software developed by Montana Fish Wildlife & Parks (MFWP 2004).

Population estimates (*N*) were calculated for each site separately as # fish/km for comparison among reaches and previous years. Observed mortalities during the marking run were recorded and excluded from the population estimates. Catch composition was determined using the combined total catch from the mark and recapture runs. The number of marked fish by site and recapture efficiency were also calculated. Recapture efficiency (R_{eff}) was calculated as

$$R_{eff} = R/C$$

where *R* is the number of recaptures collected and *C* is the total number of fish collected during the recapture run.

Average wetted stream widths for each transect were collected the week following the recapture efforts to estimate density for each target species. Transect widths were measured with a Leica LRF 900 Rangemaster rangefinder at 10 randomly-selected locations within each electrofishing transect. Transect waypoints were marked for future replication using a Magellan Sporttrack Topo GPS (Appendix A).

Results

Pelican Hazing

Pelicans were actively hazed 48 times during the hazing effort. Three quarters of the hazing events involved group sizes of 1-10 pelicans. Only six percent involved groups of 20 pelicans or more. Hazing occurred throughout the area; however, pelicans tended to concentrate on private property located upstream of Highway 20 and downstream of the IDFG’s Point of Rocks West fishing access site (Figure 18). Soft hazing (e.g. approach by vehicle, yelling, arm movements) was less effective and never resulted in an initial fright response. Pelican flights following this type of hazing resulted in short flight distances with pelicans immediately returning to the creek in 21 of 24 attempts.

Use of pyrotechnics typically was the most effective hazing technique. Good or mild fright responses were common when using pyrotechnics. Whistler rockets invoked immediate responses in 91% of attempts, whereas cracker shells invoked immediate responses in 15% of attempts. We observed that flight distance after hazing did not differ substantially between soft hazing and cracker shells. For both methods, pelicans often returned to the area on the same day. However, pelicans hazed with whistle rockets flew out of the valley, and did not return that day (100% of attempts).

Trout Survey

Marking and recapture runs were completed at Stalker creek on June 21st and July 19th, respectively. Marking and Recapture runs at Silver Creek (Cabin and Martin Bridge) were completed in June 22nd and 28th respectively. Habitat data was collected in mid-July 2016. Transect length at the lower Stalker Creek, Cabin, and Martin Bridge locations was 1,400, 1,150, and 1,100 m, respectively. Mean transect width at the lower Stalker Creek, Cabin, and Martin Bridge locations was 8.5, 27.4, and 15.6 m, respectively.

Lower Stalker Creek

Trout species composition in Stalker Creek included 40% Rainbow Trout (*n* = 250), 59% Brown Trout (*n* = 369) and 1% Brook Trout (*n* = 4). Total length of sampled Rainbow Trout ranged from 35 to 408 mm (Figure 20). Weight of sampled Rainbow Trout ranged from 3 to 457 g. Total length of sampled Brown Trout ranged from 55 to 645 mm (Figure 21). Total weight of sampled Brown Trout ranged from 1 to 2,267 g.

A total of 155 and 95 Rainbow Trout were collected in the Lower Stalker Creek transect during the marking and recapture runs, respectively. The estimated number of Rainbow Trout in the sample reach (≥ 100 mm) was 575 ± 206 (95% CI; Table 16), equating to 416 Rainbow Trout/km in Stalker Creek. Capture efficiency was 25%, for all length groups. A total of 138 and 231 Brown Trout were collected in the Lower Stalker Creek transect during the marking and recapture runs, respectively. The estimated number of Brown Trout in the sample reach (≥ 100 mm) was 473 ± 132 (95% CI), equating to 342 Brown Trout/km. Capture efficiency was 23 %, for all length groups.

Silver Creek – Cabin transect

Trout species composition in the Silver Creek Cabin transect included 35% Rainbow Trout (*n* = 72) and 65% Brown Trout (*n* = 133). Total length of sampled Rainbow Trout ranged from 54 to 450 mm (Figure 22). Relative stock density (RSD – 400) was 29%. Weight of sampled Rainbow Trout ranged from 1 to 791 g. Total length of sampled Brown Trout ranged from 68 to 655 mm (Figure 23). Relative stock density (RSD – 400) was 44%. Weight of sampled Brown Trout ranged from 3 to 2,798 g.

A total of 35 and 28 Rainbow Trout were collected in the Silver Creek Cabin transect during the marking and recapture runs respectively. The estimated number of Rainbow Trout in the sample reach (≥ 100 mm) was 149 ± 90 (95% CI) equating to 130 Rainbow Trout/km. Capture efficiency was 21% for all length groups. A total of 24 and 31 Brown Trout were collected in the Silver Creek Cabin transect during the marking and recapture runs, respectively. The estimated number of Brown Trout in the sample reach (≥ 100 mm) was 80 ± 39 (95% CI) equating to 70 Brown Trout/km. Capture efficiency was 29% for all length groups.

Silver Creek – Martin Bridge transect

Trout species composition in the Silver Creek Martin Bridge transect included 6% Rainbow Trout (*n* = 21) and 94% Brown Trout (*n* = 343). Total length of sampled Rainbow Trout ranged from 67 to 450 mm (Figure 24). Weight of sampled Rainbow Trout ranged from 3 to 785 g. Relative stock density (RSD–400) was 25%. Total length of sampled Brown Trout ranged from 60 to 651 mm (Figure 25). Relative stock density (RSD – 400) was 34%. Weight of sampled Brown Trout ranged from 2 to 3,150 g.

A total of 7 and 13 Rainbow Trout were collected in the Silver Creek Martin Bridge transect during the marking and recapture runs, respectively. Insufficient recapture of Rainbow Trout prevented a population estimate in this reach. A total of 148 and 172 Brown Trout were collected in the Silver Creek Martin Bridge transect during the marking and recapture runs, respectively. Estimated number of Brown Trout in the sample reach (≥ 100 mm) was 437 ± 100 (95% CI) equating to 520 Brown Trout/km. Capture efficiency was 33% for all length groups.

Discussion

Pelican Hazing

This was the first effort to reduce pelican predation of Silver Creek's trout population. Hazing efforts resulted in disrupted foraging habits for a group of 30-50 pelicans. The largest group encountered on Silver Creek by hazers was 40 pelicans. Ponds located on private land northeast of Picabo, Idaho were suspected to hold larger numbers of pelicans. IDFG had access to this property and ponds; however, hazing staff never encountered large groups of pelicans here.

Private land owners, non-governmental organization staff, and other IDFG staff reported large number of pelicans feeding in Silver Creek as early as mid-April. Our effort started at least a month afterwards in large part due to hiring difficulties and funding limitations. Hazing earlier when pelicans first arrive in the area might have been more effective and proactive deterrent rather than retroactively chasing actively foraging pelicans after they had become habituated to foraging in an area. IDFG staff was able to disrupt but not eliminate pelican foraging on Silver Creek during daylight hours. Pelicans are known to actively forage at night also (Luciano et al. 2018), and we did not haze at night or attempt to qualitatively assess predation at night. Therefore, we are uncertain whether predation was reduced or to what extent.

Collectively, it appears as though 30-50 pelicans visited Silver Creek daily in 2016. Assessing the predation rate of pelicans is important especially if pelican numbers continue to increase. Furthermore, if predation management is deemed necessary, staff should apply the most efficient method.

Trout Survey

Rainbow Trout composition, CPUE, and population estimates for all trend monitoring sites have decreased compared to the 2013 survey. Similarly, Brown Trout density estimates decreased compared to the 2013 for all sites. Population structure for Rainbow Trout in 2016 was the lowest ever recorded since consistent sampling began in 2001.

Historically, Rainbow Trout was the most common trout species in Silver Creek, and Stalker Creek was assumed to be the primary spawning area and habitat. Gradually during the last two decades, the proportion of Rainbow Trout has decreased and correspondingly the proportion of Brown Trout has increased. The 2016 results show continuation of this trend. Surveys during the early 2000s have demonstrated approximately a 60% species composition of Rainbow Trout in Stalker Creek and Silver Creek Cabin trend sites (Figure 26). However this relative composition has inverted and Brown Trout are now more common than Rainbow Trout at all monitoring sites. Brown trout have consistently outnumbered Rainbow Trout by a wide margin in the lower reaches of Silver creek near the Martin Bridge. This trend continued and became more pronounced with the sample consisting of 94% Brown Trout. Continued proportional increases of Brown Trout may result in reduced overall angler catch rates or shift in size structure. Since this is a relatively new phenomena, it important to gain understanding of angler opinion regarding species preferences.

Relative weights for Rainbow Trout sampled in all three sampling reaches were well below 100 (Figures 27-28). This may be a result of sample timing, as IDFG trend sampling occurs after Rainbow Trout spawn when fish are typically in poor body condition. Collectively, Brown Trout relative weights were below 100, but still suggest fish are in fair to good condition (Figure 29). Because both trout species were 100 relative weight, monitoring and documenting trends will be important to determining if resource limitation is an issue.

Relative stock densities were measured for all three sample sites. Relative stock densities (RSD – 400) were determined for Rainbow Trout and Brown Trout collected in each site to describe the available and preferred component of the population. RSD-400 was calculated as the number of fish ≥ 400 mm divided by the number of fish ≥ 200 mm (Ney 1993). Trends in Relative stock densities (RSD – 400) have been measured since 2001. Relative stock densities (RSD – 400) for Rainbow Trout showed an increase in the Stalker Creek sample as compared to 2013. Relative stock densities (RSD – 400) for Rainbow Trout showed an increasing trend in both the Cabin and Martin Bridge sampling sections as compared to 2013 (Figure 30). Relative stock densities (RSD – 400) for Brown Trout showed a decrease in the Stalker Creek sampling as compared to 2013. Relative stock densities (RSD – 400) for Brown Trout showed an increasing trend in both the Cabin and Martin Bridge sampling sections as compared to the 2013 (Figure 30).

Silver Creek as a whole seems to be experiencing a shift in community structure towards more Brown Trout. This is best illustrated by catch composition trends from 2001 to 2016. Similarly, relative stock densities suggest larger Brown Trout are becoming more common. And although Rainbow Trout are growing to trophy lengths, relative weights of Rainbow Trout are trending noticeably downward. Collectively, the findings of this study suggest a shift is occurring and is resulting in relatively more Brown Trout, larger Brown Trout, and to poor condition Rainbow Trout. Rainbow Trout have been a popular component of this fishery; gaining better understanding of biological mechanisms causing this sift and angler desires for the future of this fishery will be important to developing appropriate management direction and actions.

Recommendations

1. Hazing efforts should be initiated earlier and timed to coincide with initial spring arrival of pelicans in Idaho.
2. The primary hazing method should be whistle rockets.
3. Pelican predation rates should be estimated using tagged wild trout to determine population effects.
4. Triennial trout population monitoring should continue to assess long-term trends and inform management direction.
5. A creel and angler opinion survey should be conducted throughout the Silver Creek drainage to assess catch rates, effort, angler exploitation, and species preferences.

FIGURES

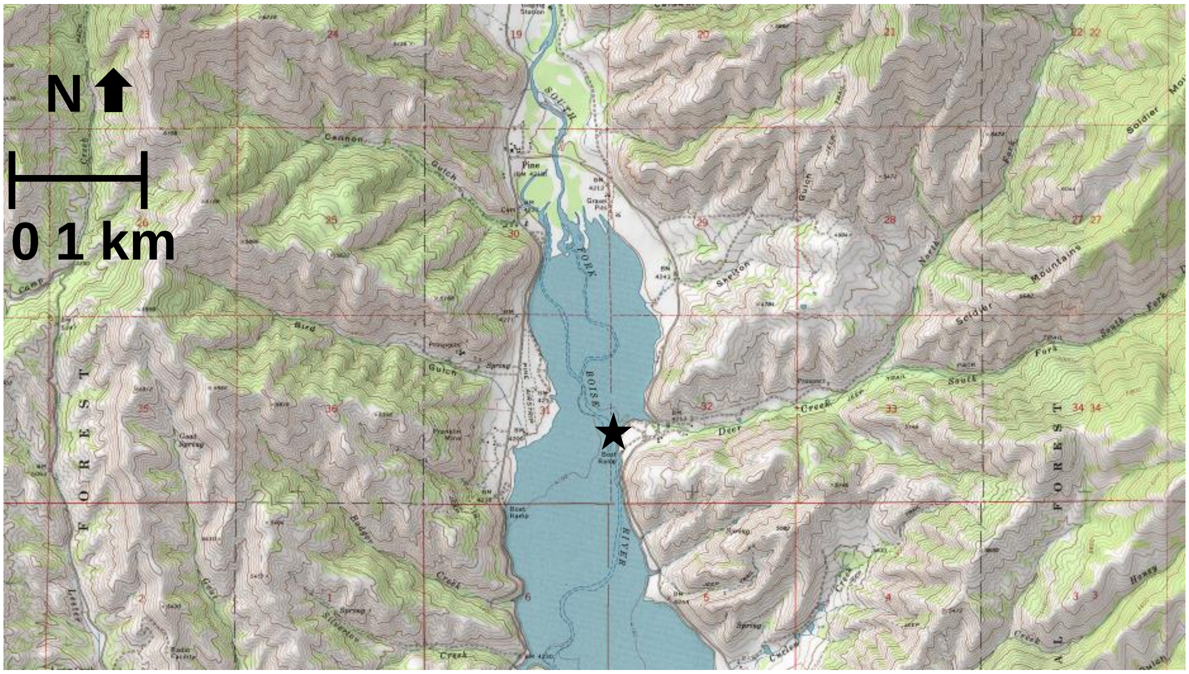


Figure 1. Anderson Ranch Reservoir in Elmore County, Idaho. Star depicts the upper reservoir boundary where staging kokanee were vulnerable to pelican predation and where hazing efforts were concentrated in 2016.

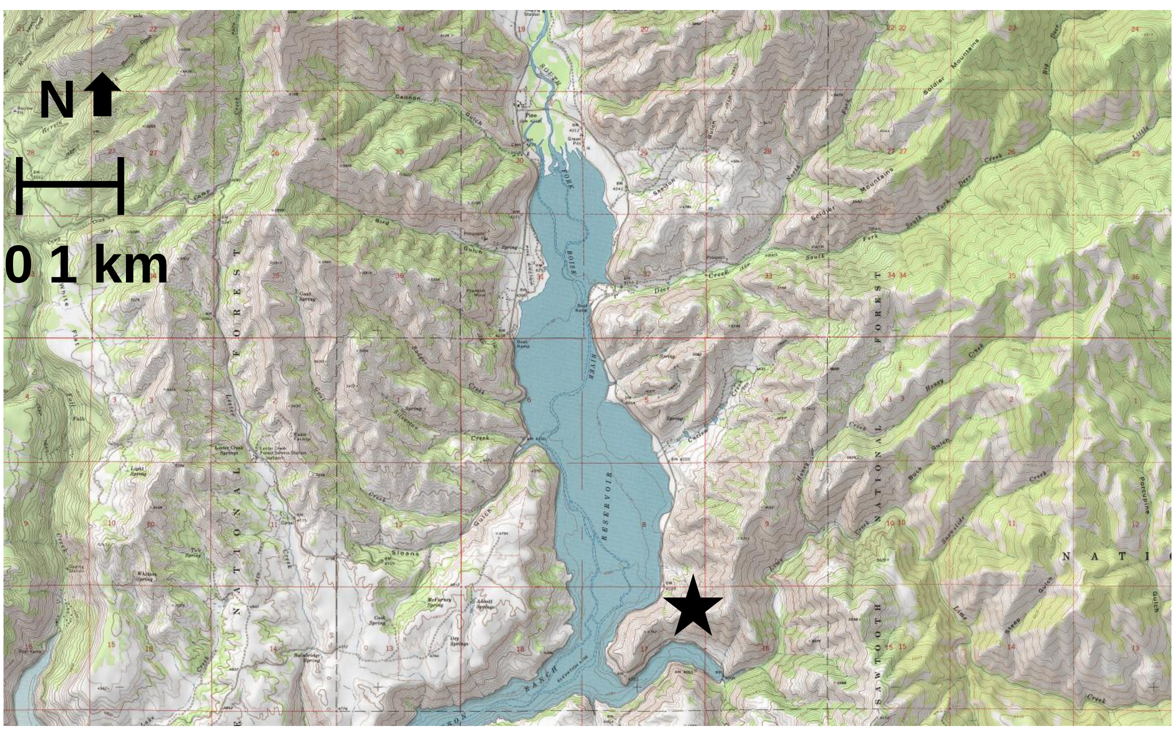


Figure 2. Anderson Ranch Reservoir in Elmore County, Idaho. Star depicts location of angler check-station location run on randomly chosen days from June 24 to August 7, 2016.

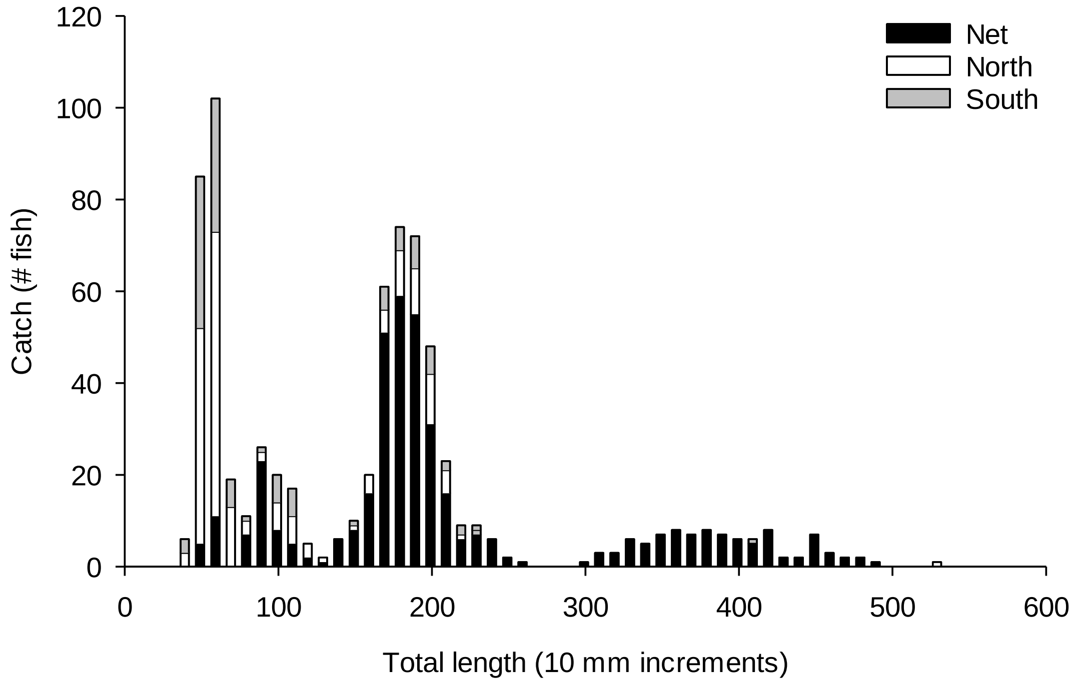


Figure 3. Total kokanee catch by length groups from North-Idaho trawl, South-Idaho trawl and gillnet in Anderson Ranch Reservoir, 2016.

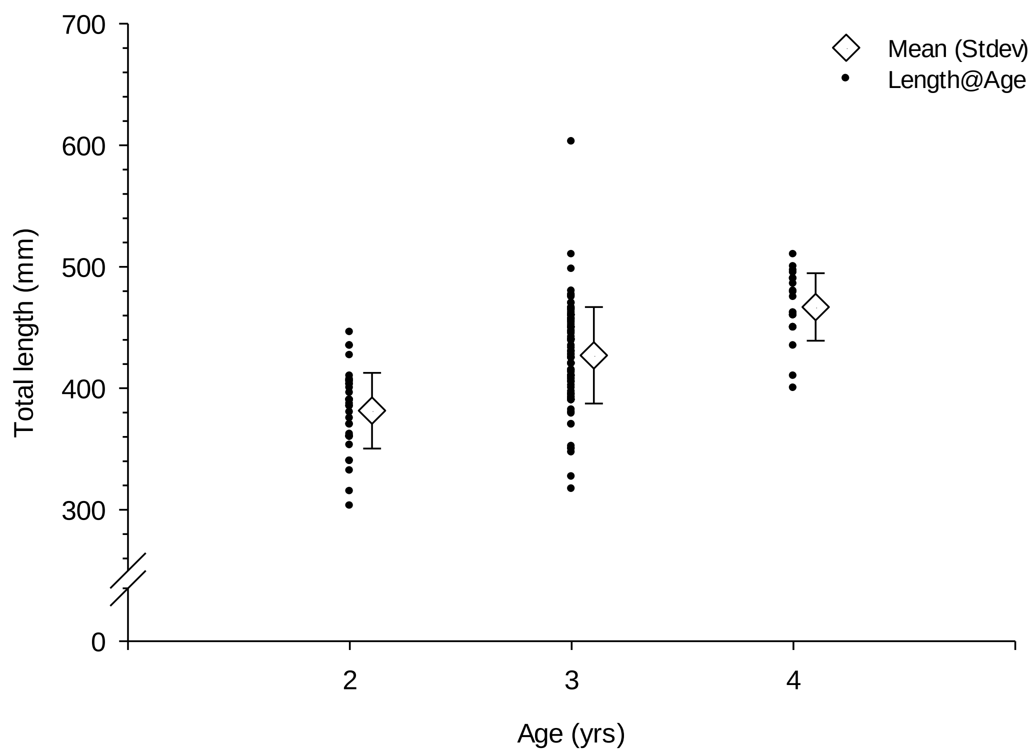


Figure 4. Length-at-age of kokanee harvested (n = 167) from Anderson Ranch Reservoir. Data from creel check stations (n = 16 days) between June 24 and August 7, 2016.

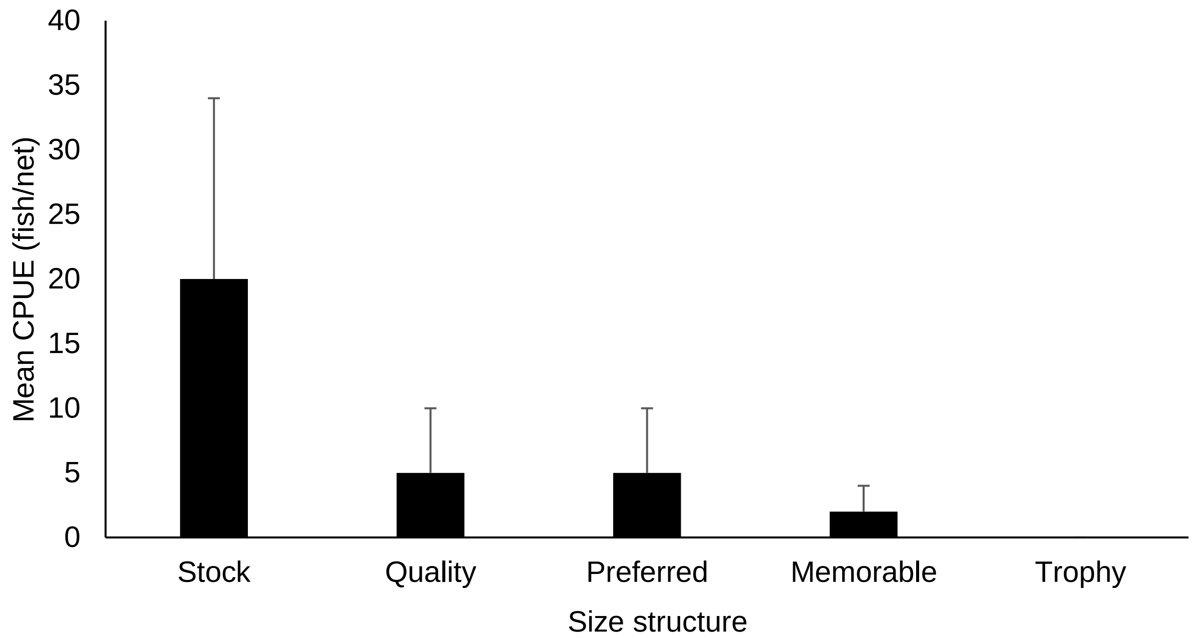


Figure 5. Mean CPUE (fish/net) by stock structure of kokanee catch (*n* = 361) from a total effort of 18 gill net nights in Anderson Ranch Reservoir sampled from July 2-3, 2016.

Figure 6. Satellite image of Bruneau Dunes Ponds (Google Earth). Top of map is north.

Figure 7. Satellite image of Magic Reservoir (Google Earth). Top of map is north

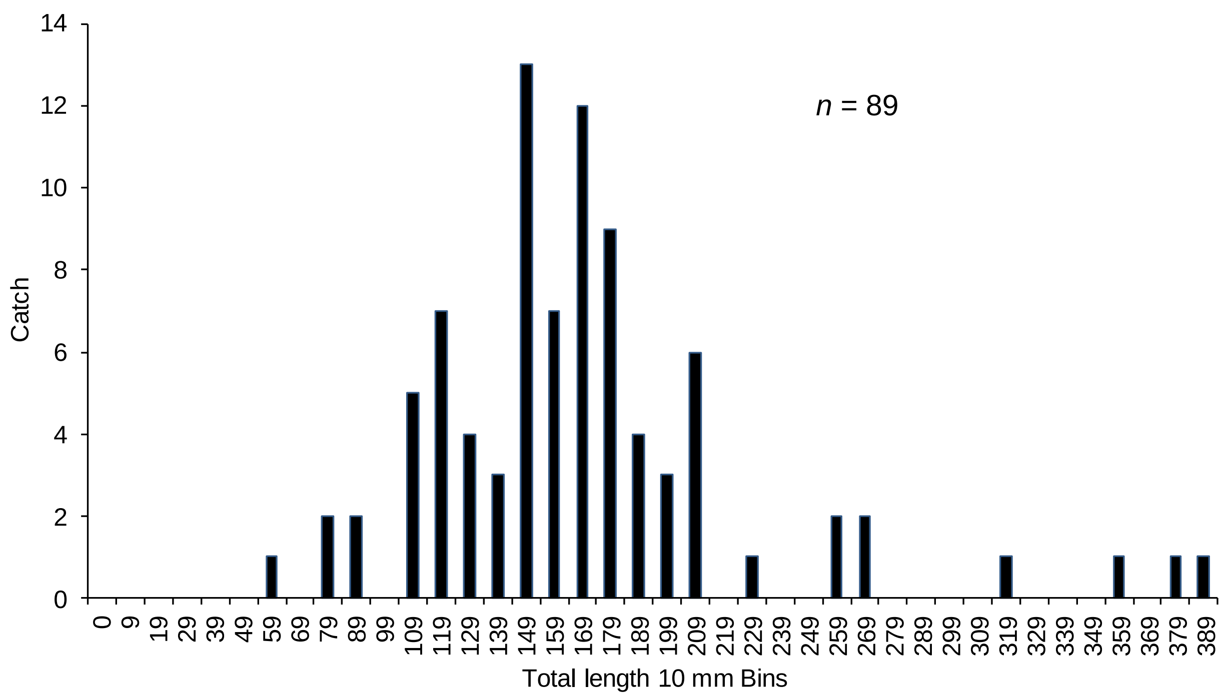


Figure 8. Length-frequency histogram for Smallmouth Bass collected in Magic Reservoir in June 2016.

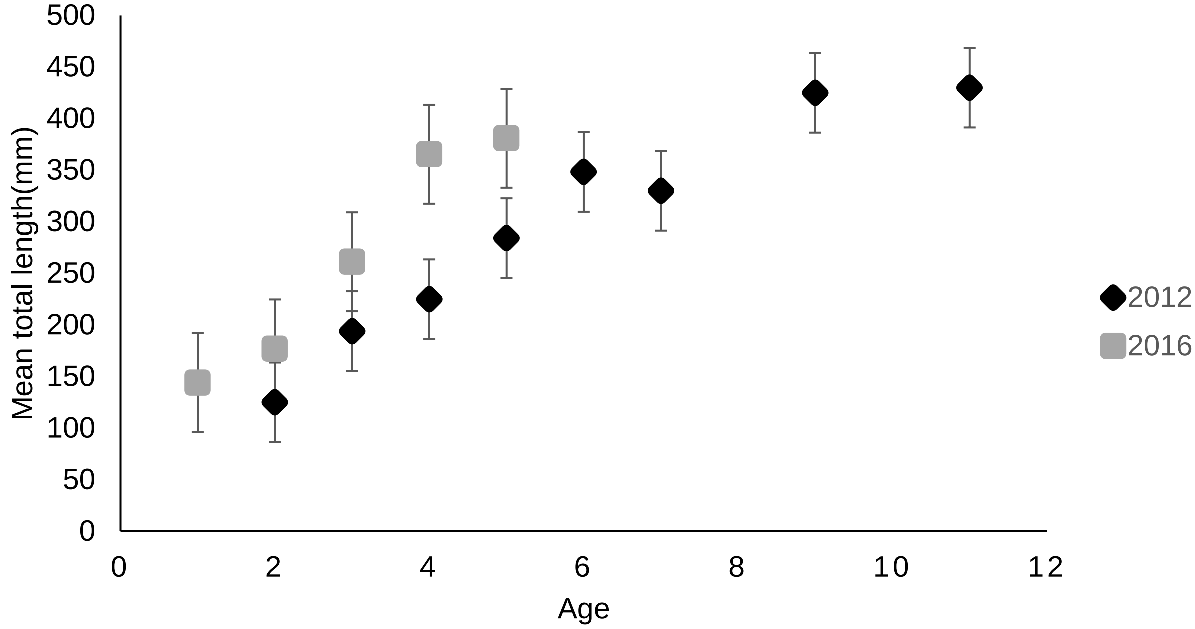
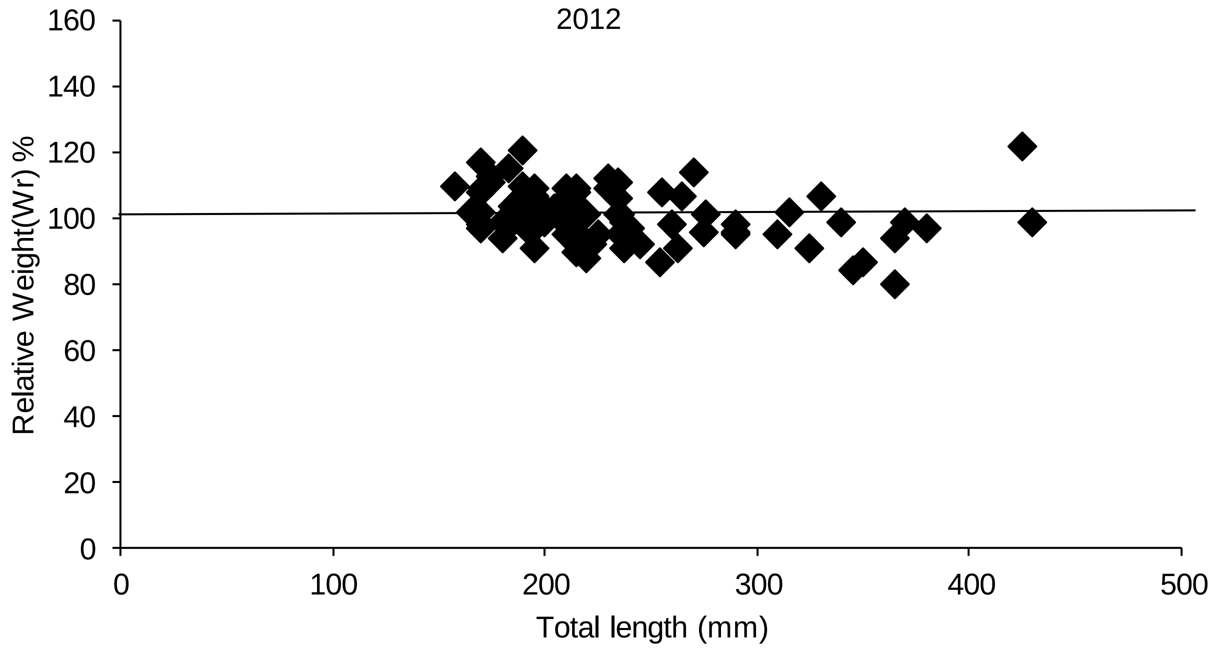


Figure 9. Length-at-age plot for Magic Reservoir Smallmouth Bass collected with electrofishing in June 2012 and 2016.



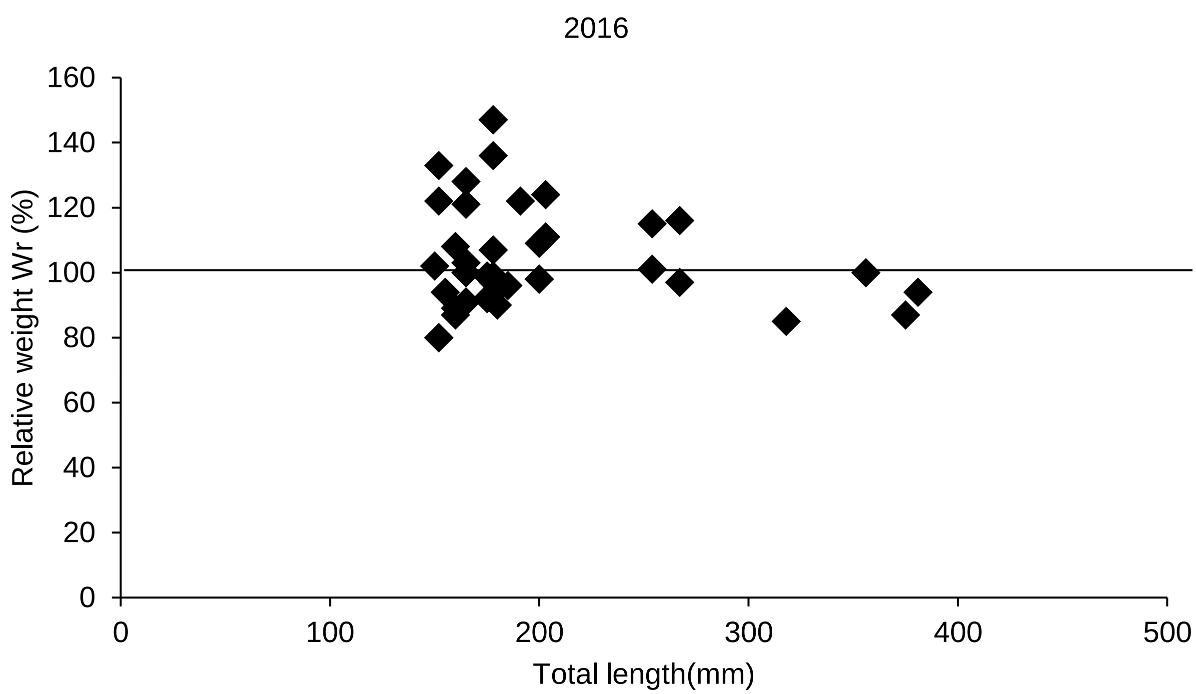


Figure 10. Comparative relative weights of Smallmouth Bass collected from Magic Reservoir with electrofishing. Samples size was 87 in 2012 and 43 in 2016.

Figure 11. Satellite image of Oakley Reservoir (Google Earth). Top of map is north.

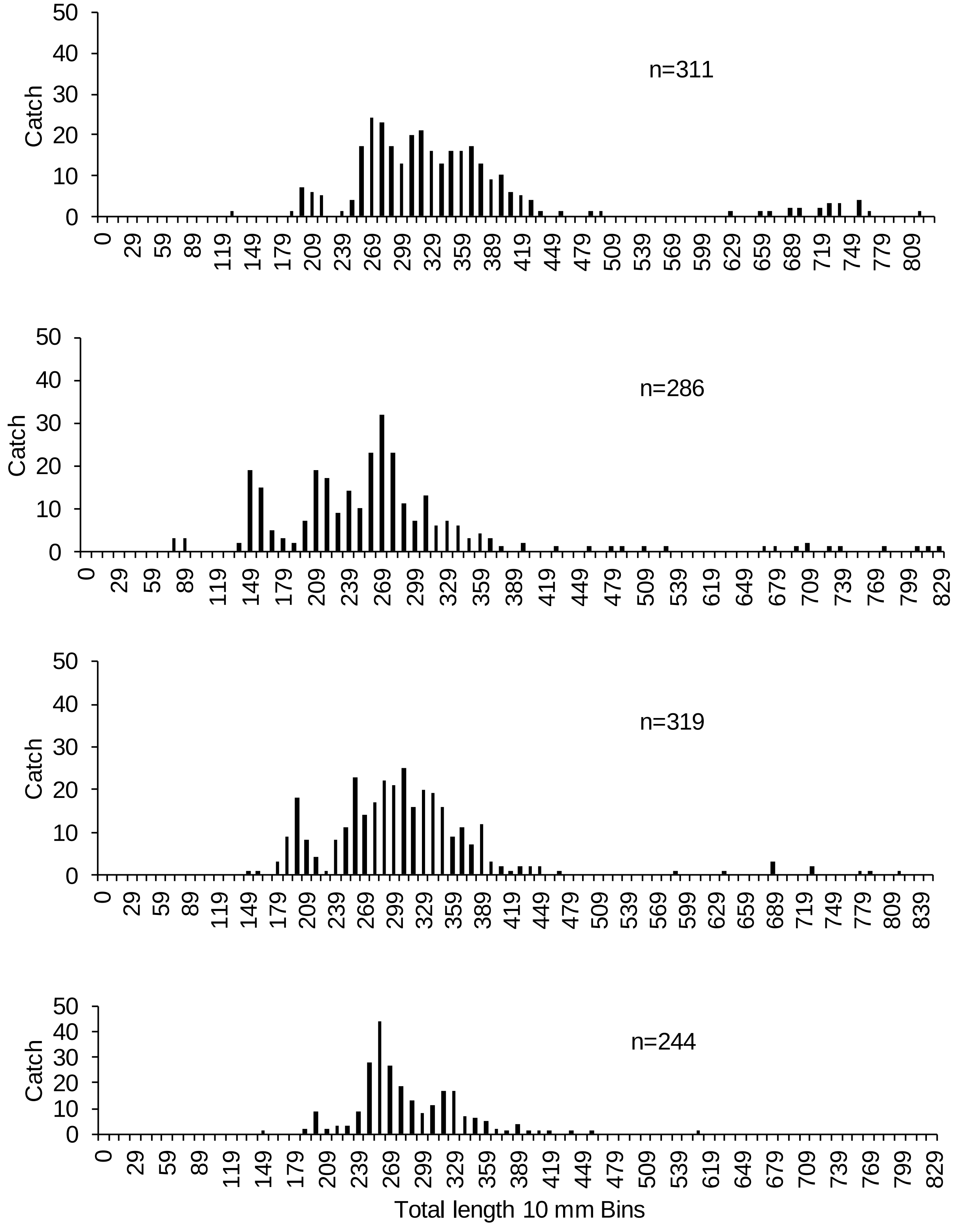


Figure 12. Comparative length-frequency histograms for Walleye collected on Oakley Reservoir in 2007(top), 2008, 2009, and 2016 (bottom) with gill nets.

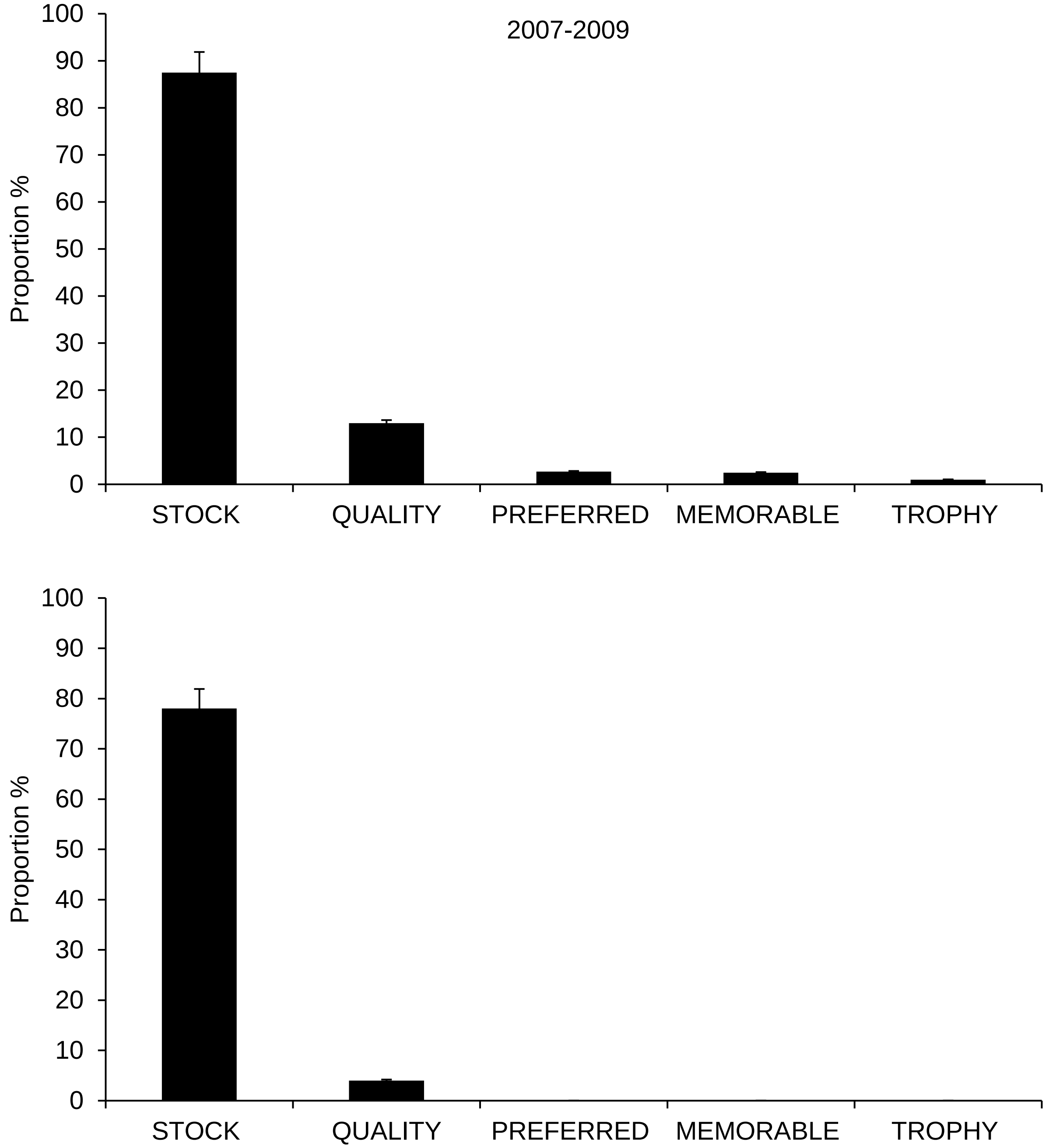


Figure 13. Catch proportion as (%) of Walleye per stock size collected in Oakley Reservoir in 2007-2009 (top) and 2016 (bottom) with gill nets

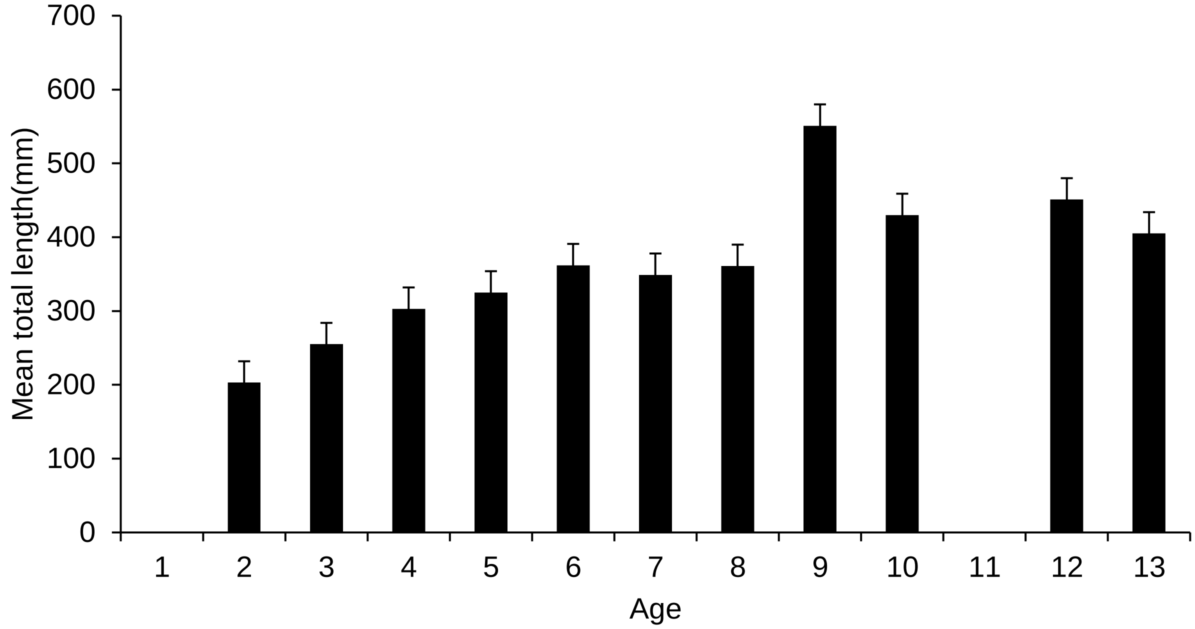


Figure 14. Length-at-age for Walleye collected from Oakley Reservoir in 2016 with gill nets.

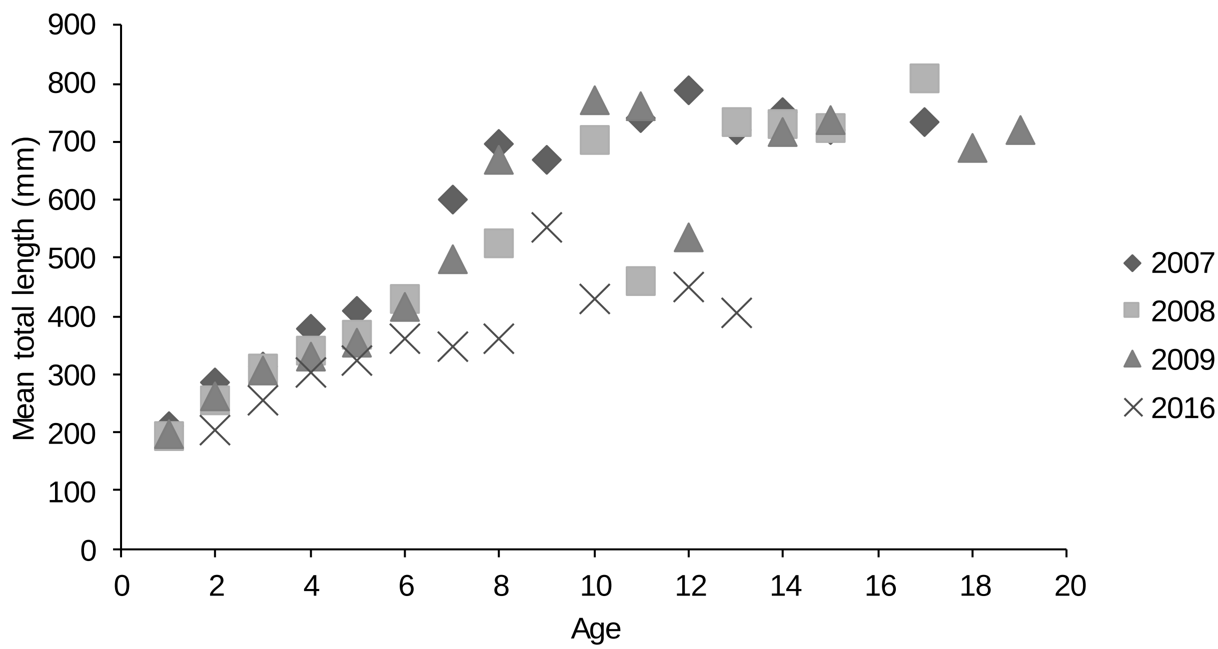


Figure 15. Length-at-age for Walleye collected in Oakley Reservoir in 2007, 2008, 2009, and 2016 with gill nets.

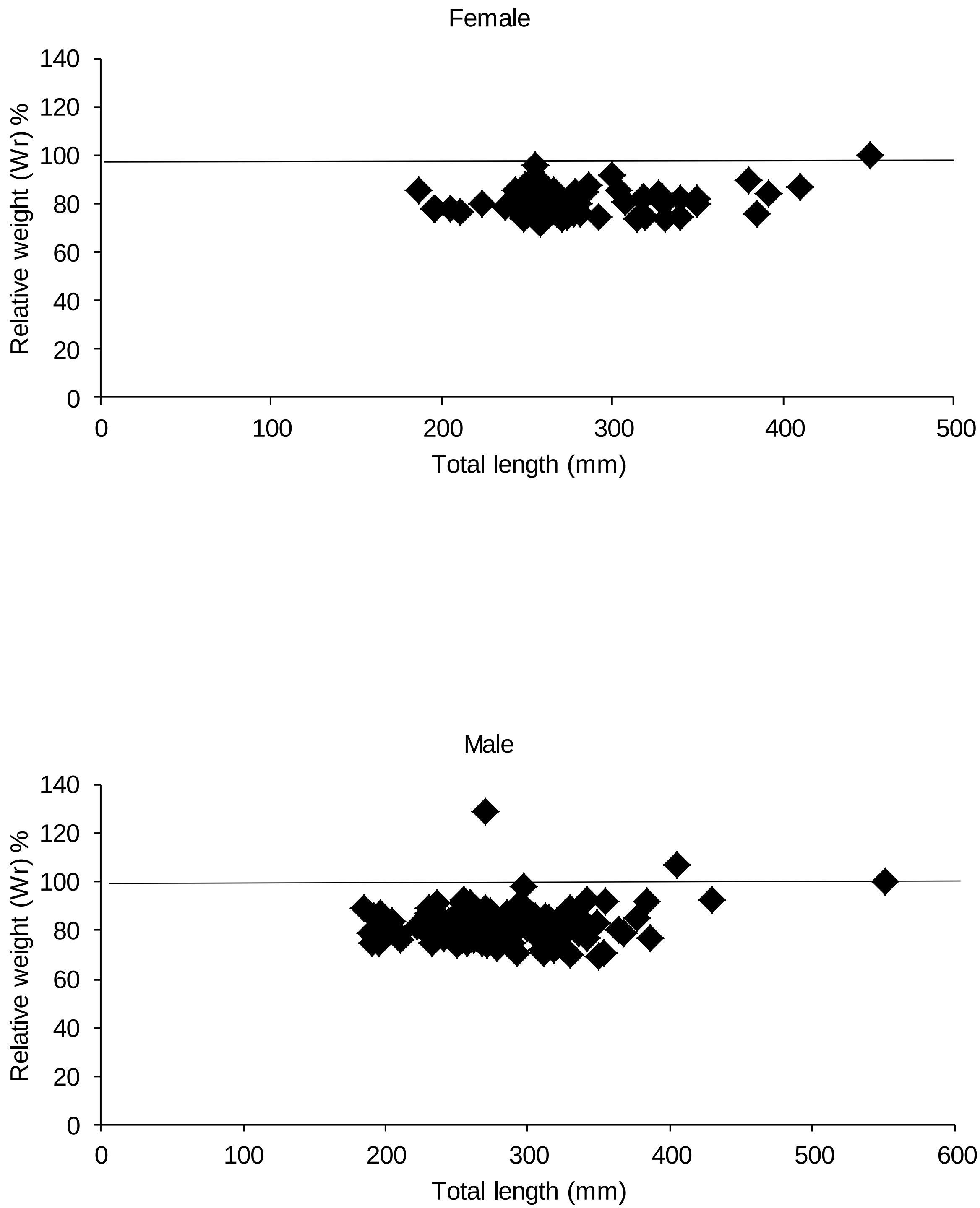


Figure 16. Relative weight of male and female Walleye collected in Oakley Reservoir in 2016 with gill nets.

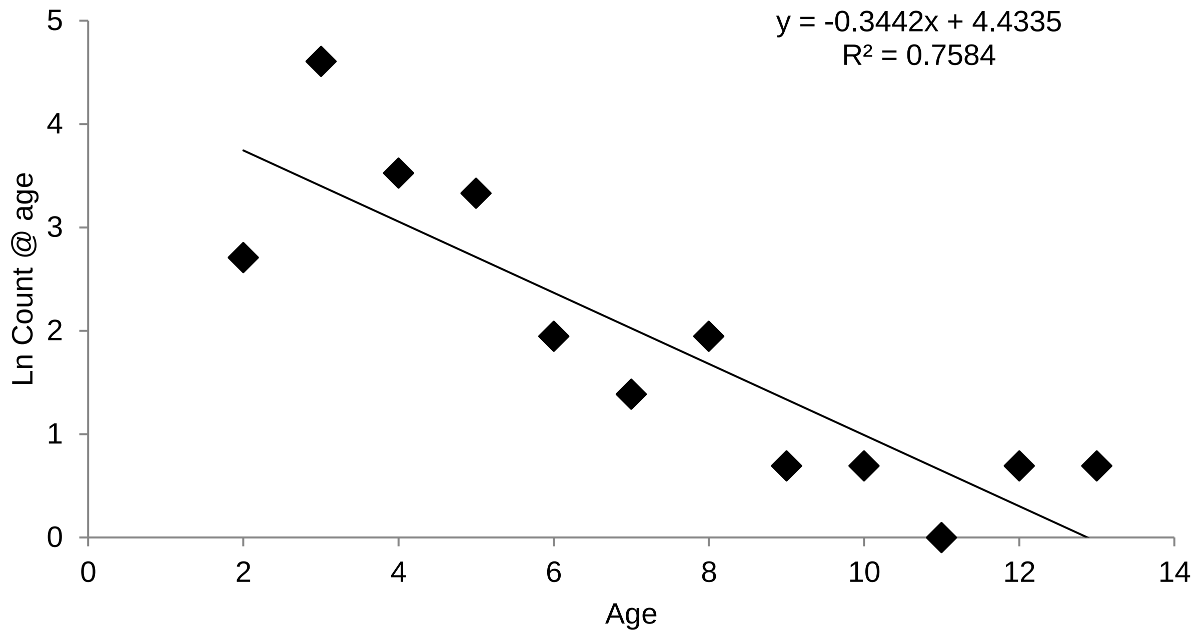


Figure 17. Catch curve for Walleye collected from Oakley Reservoir in 2016 with gill nets.

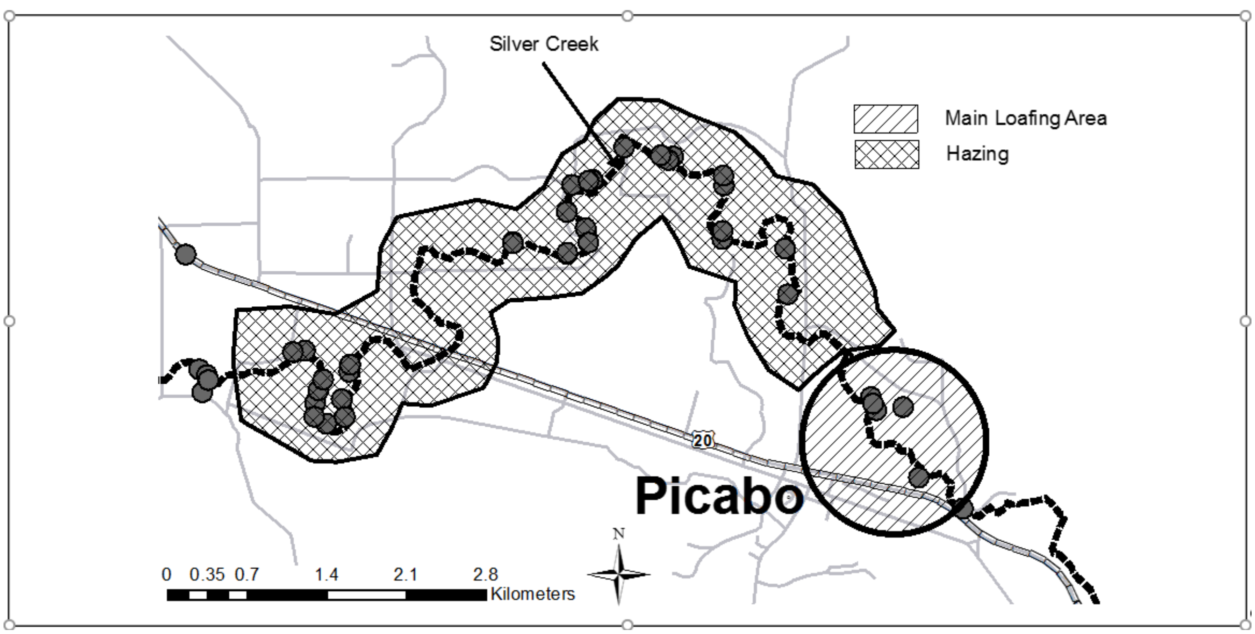


Figure 18. Map depicting area on Silver Creek, Blaine County where pelican foraging and loafing occurs. Hazing occurred in both highlighted areas and is denoted with gray dots

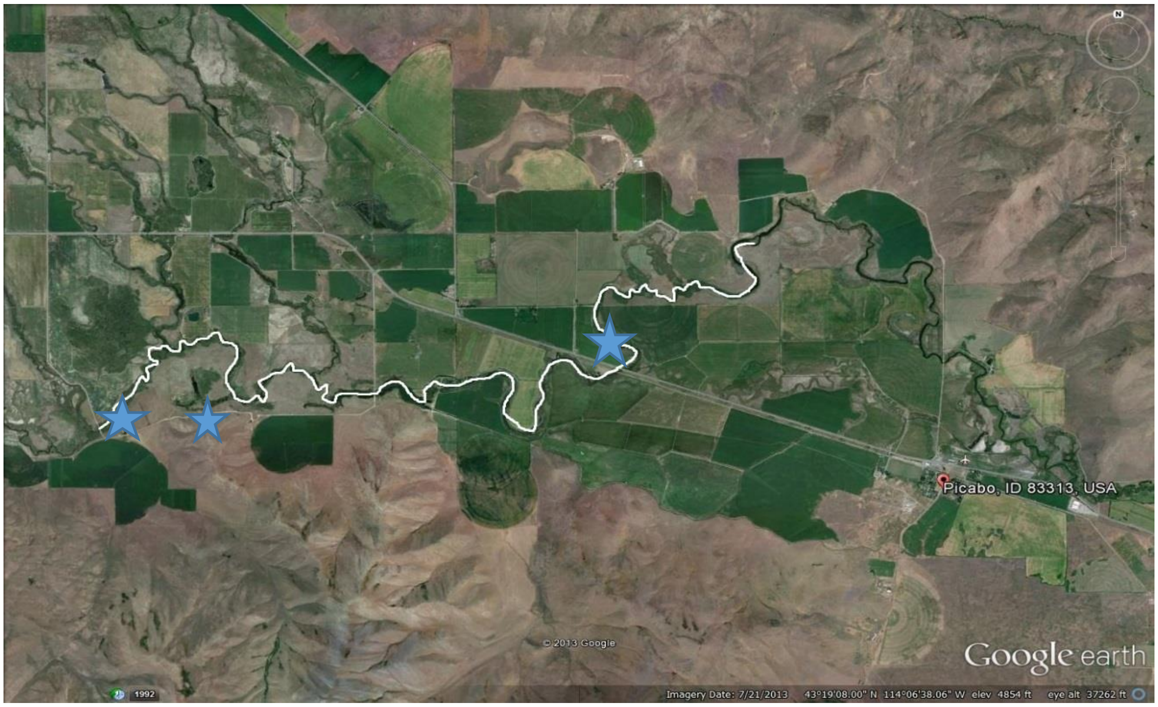


Figure 19. Satellite image of Silver Creek (Google maps). Top is north. Stars indicate the location of the three sampling transects.

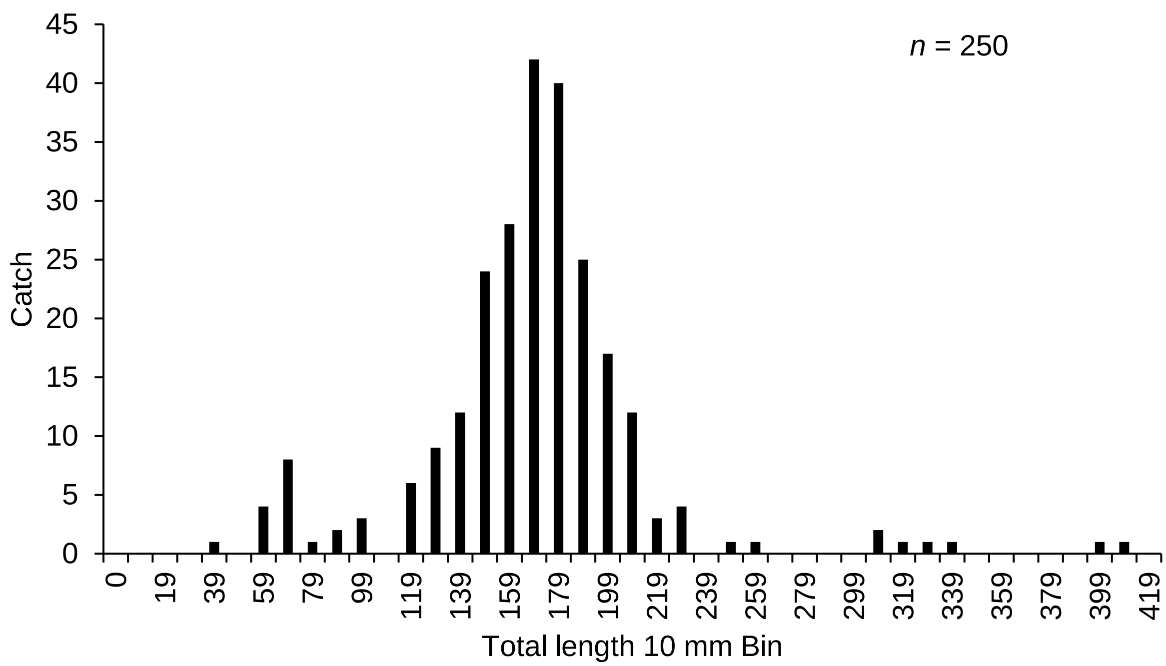


Figure 20. Length-frequency histogram of Rainbow Trout collected in Stalker Creek in 2016 with electrofishing.

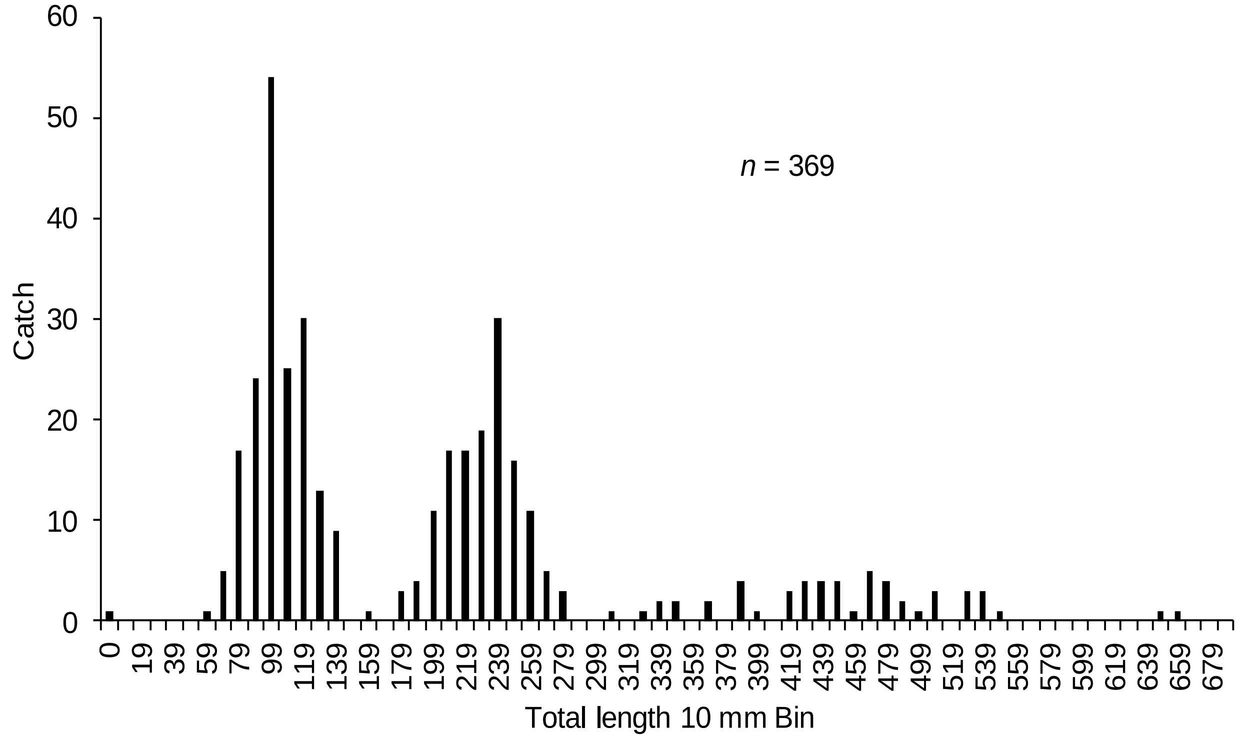


Figure 21. Length-frequency histogram of Brown Trout collected in Stalker Creek in 2016 with electrofishing.

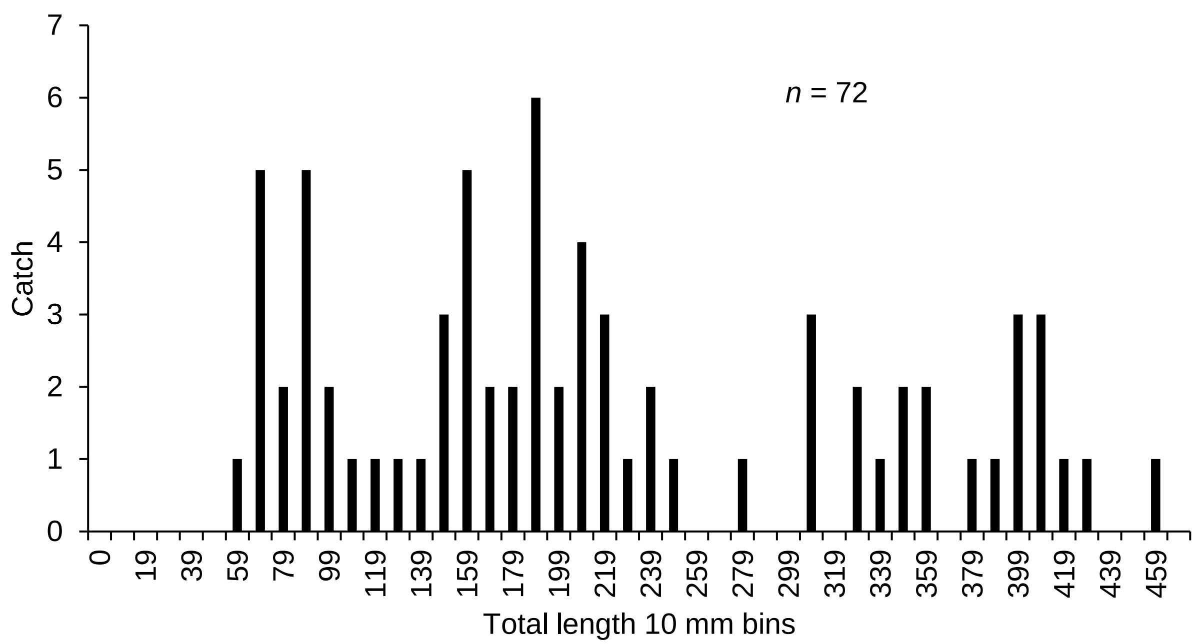


Figure 22. Length-frequency histogram of Rainbow Trout collected in Silver Creek (Cabin section) in 2016 with electrofishing.

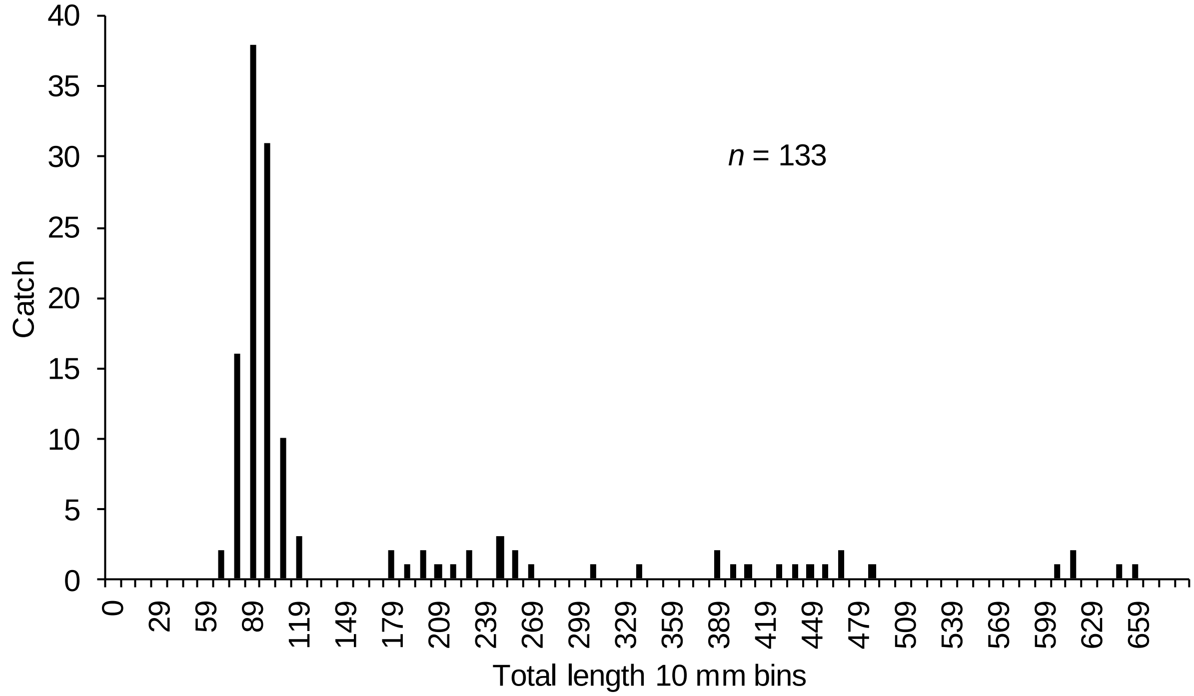


Figure 23. Length-frequency histogram of Brown Trout collected in Silver Creek (Cabin section) in 2016 with electrofishing.

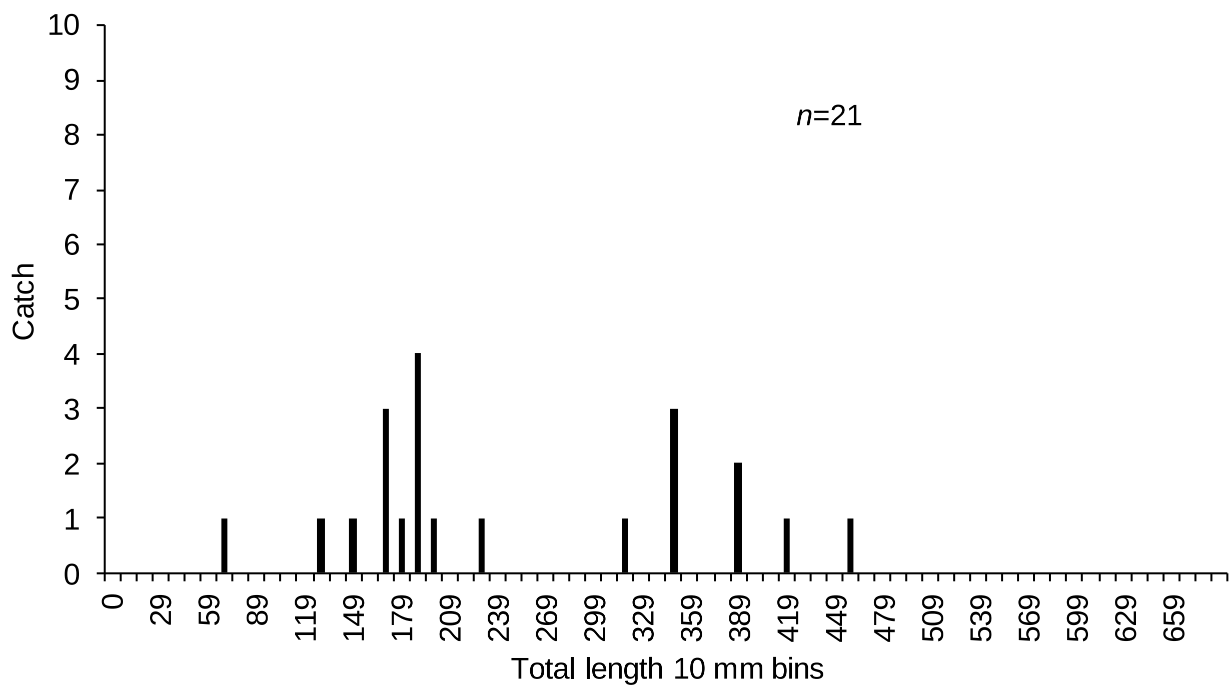


Figure 24. Length-frequency histogram of Rainbow Trout collected in Silver Creek (Martin Bridge section) in 2016 with electrofishing.

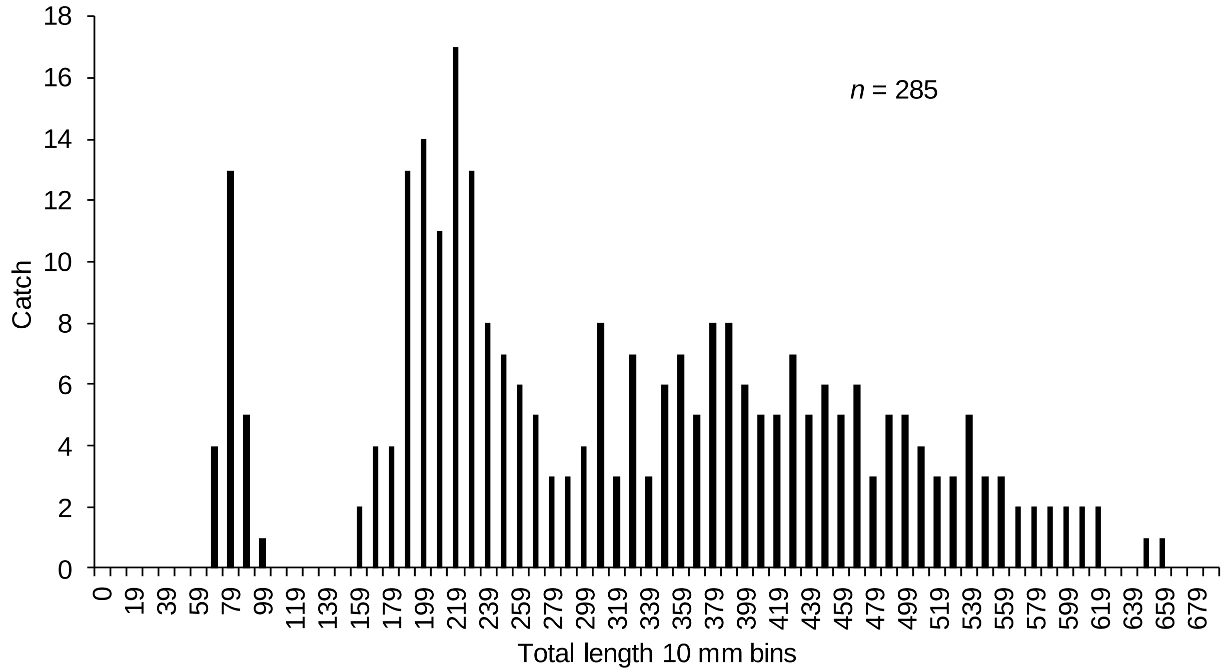


Figure 25. Length-frequency histogram of Brown Trout collected in Silver Creek (Martin Bridge section) in 2016 with electrofishing.

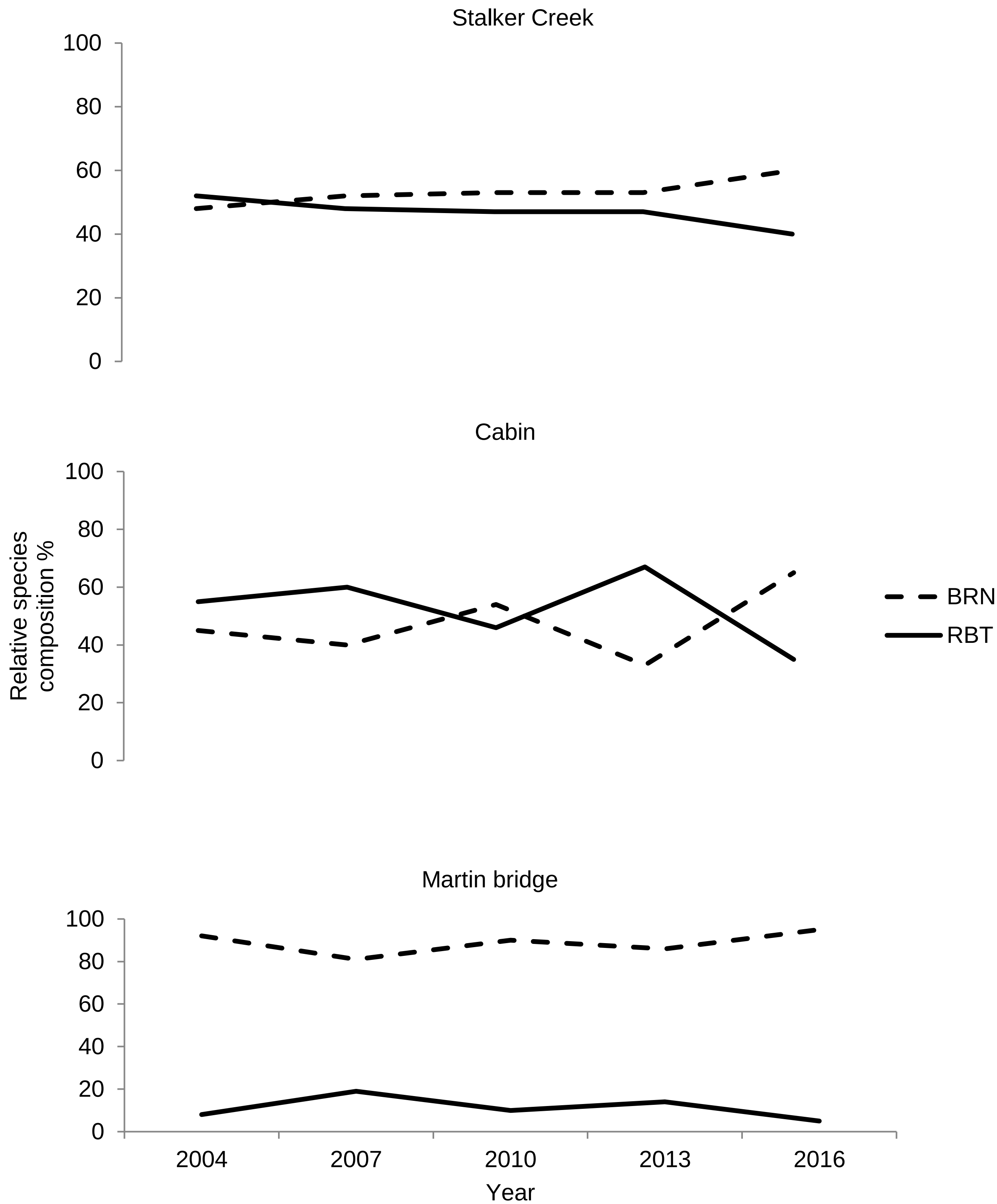


Figure 26. Relative composition of Brown and Rainbow Trout in three reaches sampled in Stalker Creek and Silver Creek 2004-2016, with electrofishing.

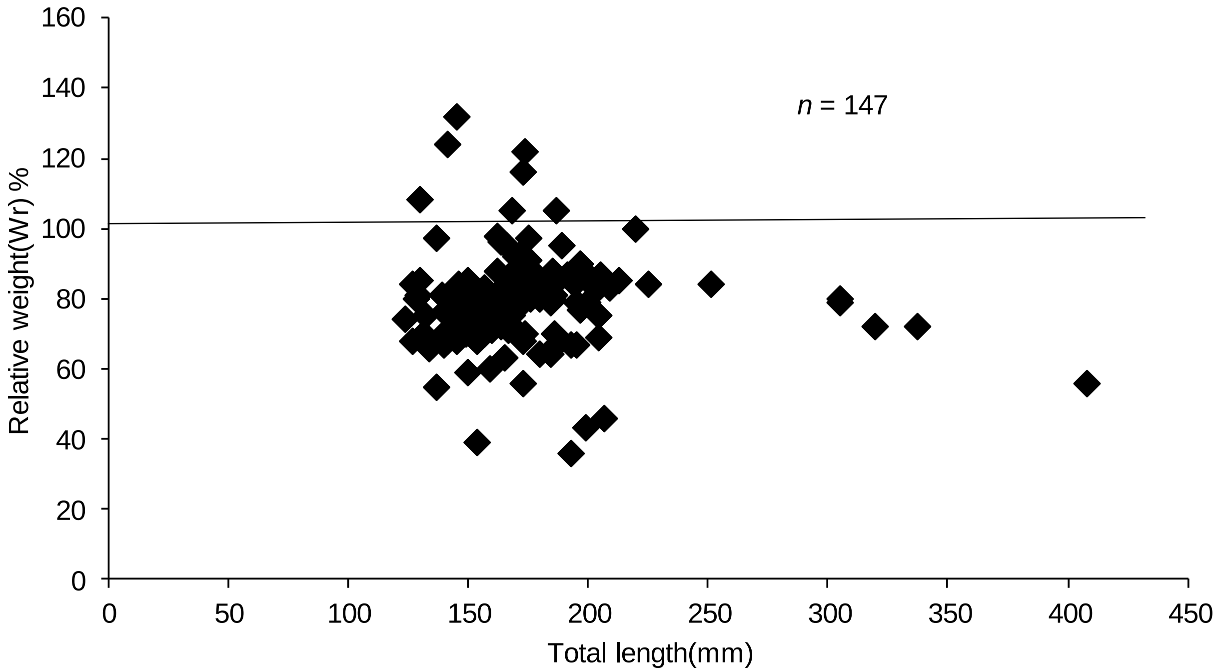


Figure 27. Relative weights of Rainbow Trout sampled in Stalker Creek in 2016 with electrofishing.

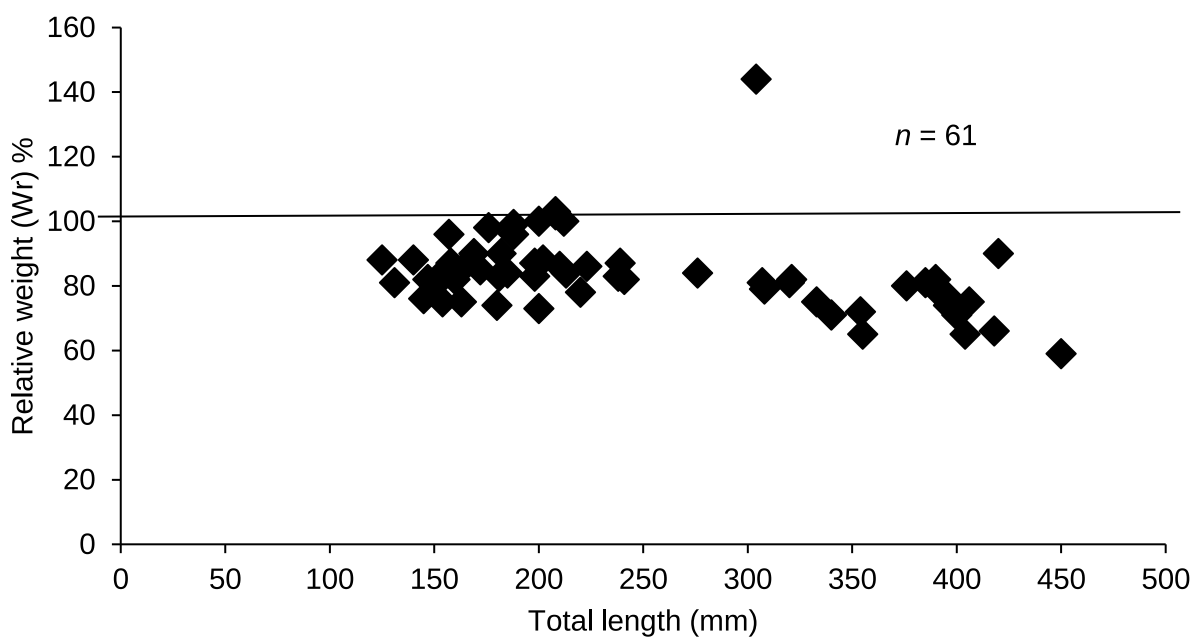


Figure 28. Relative weights of Rainbow Trout sampled in Cabin section Silver creek in 2016 with electrofishing.

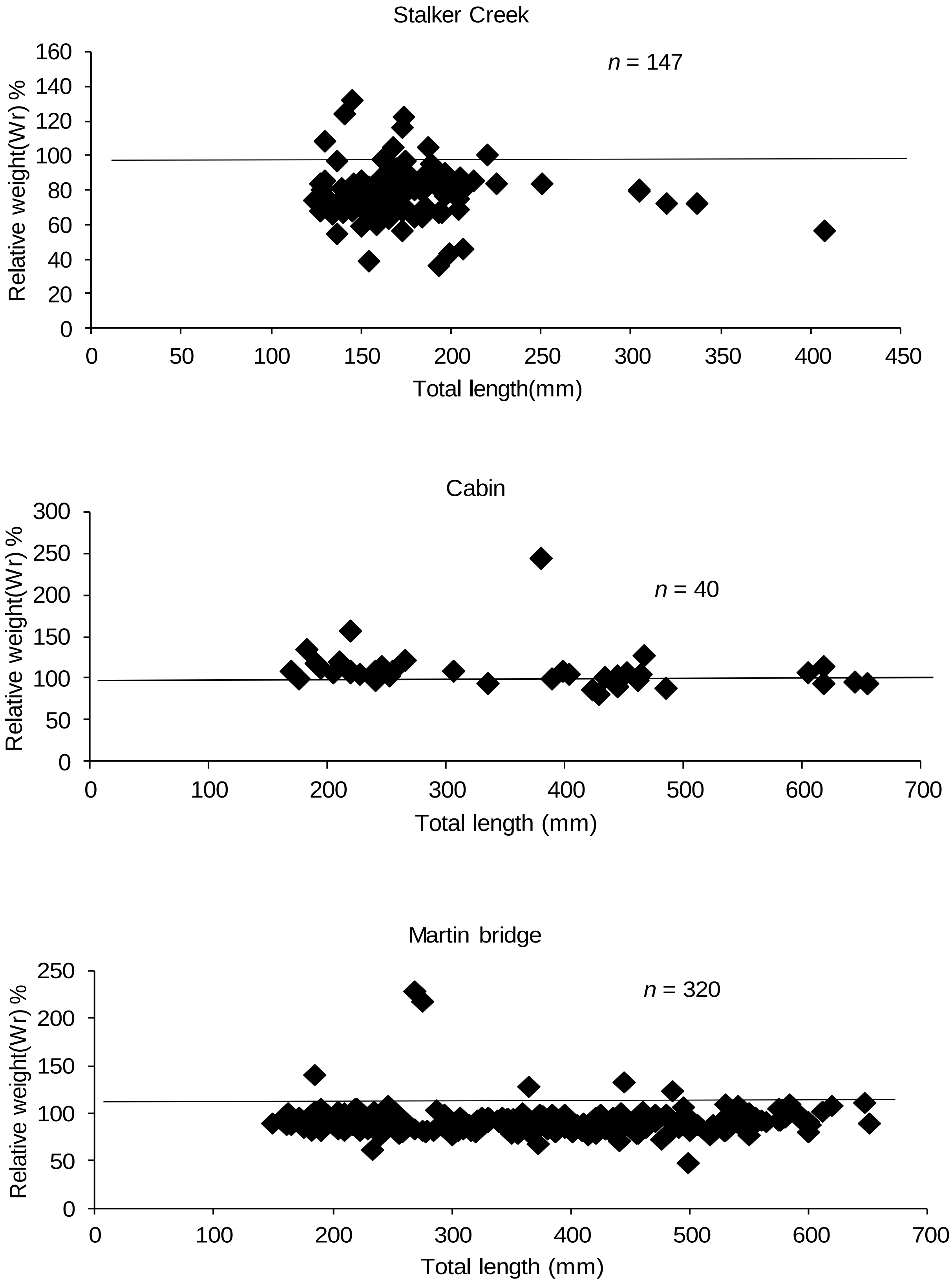


Figure 29. Relative weights of Brown Trout in three reaches sampled in Stalker Creek and Silver Creek in 2016 with electrofishing.

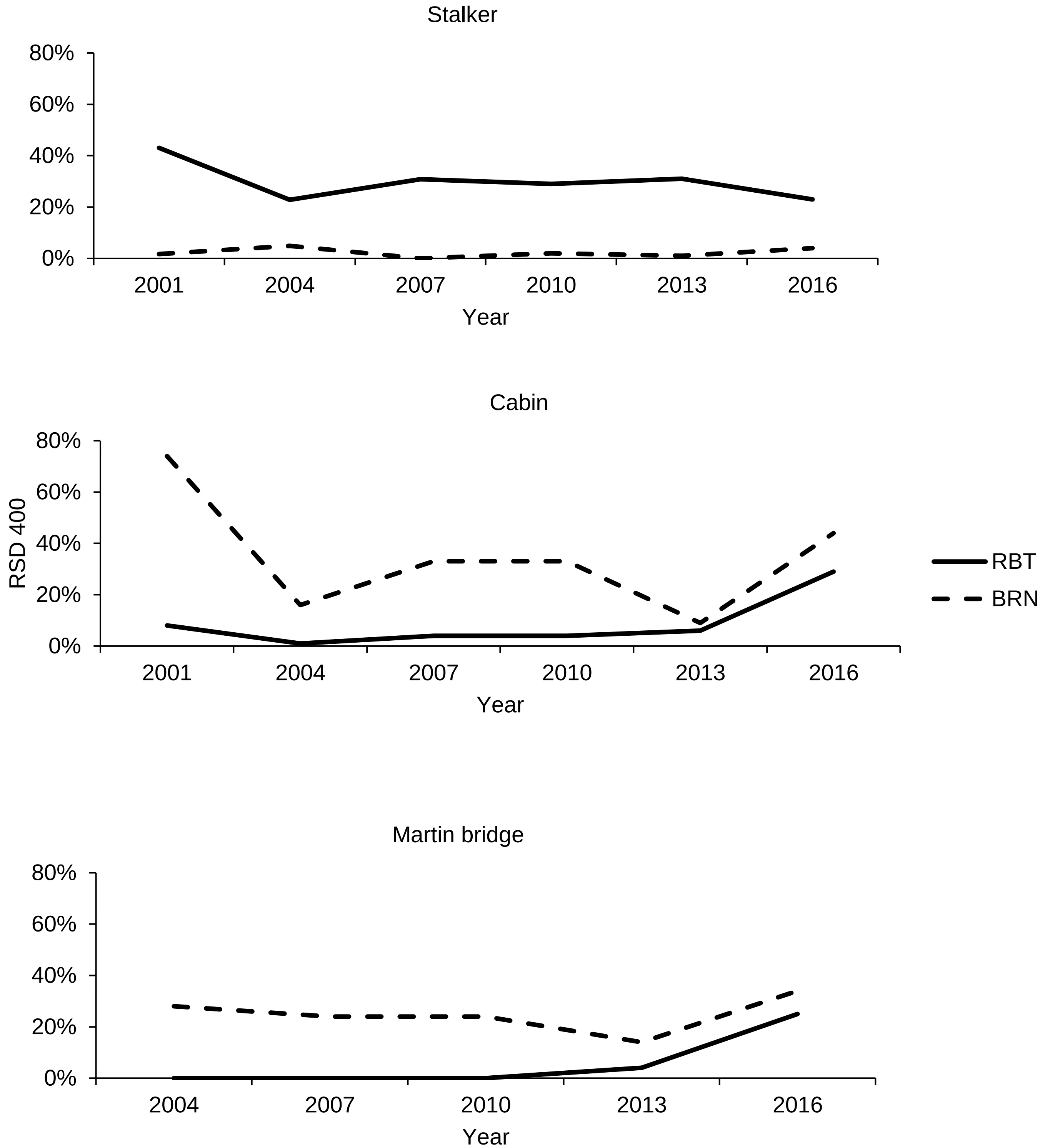


Figure 30. Relative stock density (RSD 400) of Rainbow and Brown Trout by survey transect and year (2001-2016) in Stalker Creek and Silver Creek, Idaho.

TABLES

Table 1. Counts of spawning kokanee in the South Fork Boise River upstream of the conflict area before (Sept. 1), during (Sept. 9) and at the end of hazing efforts (Sept. 16)

		Kokanee count		
Location #	Location description OR name	9/1/2016	9/9/2016	9/16/2016
1	Pine Bridge	0	6	0
2	Sheep Bridge (just outside of Pine)	0	0	0
3	Boulder hole- downstream from Weir	0	0	0
8	Fallen tree above cabin and hole downstream	18	18	12
10	Chaparral Campground	7	19	61
12	Ranger Station	0	10	10
14	Viginia Gulch Trail 037	20	11	6
	Total	45	64	89

Table 2. Check station results from kokanee creel interviews at Anderson Ranch Reservoir's Curlew boat ramp between June 24 and August 7, 2016.

			Catch		Harvest	
Date	Anglers	Total hrs.	Fish	Rate (Stdev)	Fish	Rate (Stdev)
06/24/2016	7	33.0	6	0.20 (0.30)	6	0.20 (0.30)
06/25/2016	30	150.0	15	0.12 (0.26)	15	0.12 (0.26)
06/26/2016	31	160.5	26	0.14 (0.19)	22	0.11 (0.19)
07/01/2016	19	109.0	52	0.39 (0.42)	52	0.39 (0.42)
07/02/2016	29	181.0	32	0.22 (0.40)	32	0.22 (0.40)
07/03/2016	8	42.0	13	0.32 (0.25)	13	0.32 (0.25)
07/05/2016	5	25.0	8	0.32 (0.72)	8	0.32 (0.72)
07/06/2016	14	72.5	41	0.72 (1.00)	25	0.38 (0.50)
07/07/2016	11	60.0	33	0.84 (1.66)	33	0.84 (1.66)
07/11/2016	21	106.0	26	0.27 (0.48)	26	0.27 (0.48)
07/16/2016	18	84.0	34	0.39 (0.29)	29	0.33 (0.29)
07/22/2016	10	38.0	2	0.07 (0.16)	2	0.07 (0.16)
07/28/2016	1	2.5	0	0.00 (0.00)	0	0.00 (0.00)
07/30/2016	3	13.5	0	0.00 (0.00)	0	0.00 (0.00)
08/05/2016	1	1.0	0	0.00 (0.00)	0	0.00 (0.00)
08/07/2016	13	43.0	0	0.00 (0.00)	0	0.00 (0.00)
All	221	1121	288	0.27 (0.57)	263	0.24 (0.51)

Table 3. Trawl sampling data by transect from two concurrent sampling efforts in Anderson Ranch Reservoir on June 30, 2016.

Trawl			Transect			Net depth (ft)		Steps			
Type	Speed (m/s)	Net mouth (m^2)	Transect	Start	End	Min.	Max.	#'s	Time (sec)	Shift [a] (Sec)	# Fish
North	1.6	4.22	Dam	2245	2304	44	77	3	180	31	31
	1.6	4.22	Rock Creek	2312	2337	44	101	5	180	34	29
	1.6	4.22	Fall Creek	2351	0012	54	113	5	180	38	30
	1.6	4.22	Narrows	0023	0051	56	113	5	180	38	33
	1.6	4.22	Lime Creek	0100	0122	56	101	4	180	39	51
	1.6	4.22	Upper Res.	0128	- -	56	89	3	180	40	29
South	1.6	6.60	Upper Res.	0210	0225	48	72	3	180	25	30
	1.6	6.60	Lime Creek	0230	0253	48	88	5	180	22	18
	1.6	6.60	Narrows	0300	0325	48	88	5	180	26	18
	1.6	6.60	Fall Creek	0333	0355	48	88	5	180	23	29
	1.6	6.60	Rock Creek	0405	0425	48	88	5	180	23	13
	1.6	6.60	Dam	0430	0448	56	88	4	180	24	119

[a] time between steps

Table 4. Trawl catch by transect from two concurrent sampling efforts in Anderson Ranch Reservoir on June 30, 2016.

		Species					
Trawler	Transect	Kok	Cnk	Lmb	Rbt	Ylp	Total
North	Dam	29		1		1	31
	Fall Creek	29					29
	Lime Creek	29				1	30
	Narrows	32	1				33
	Rock Creek	48		1		2	51
	Upper Res.	27		1		1	29
	Total	194	1	3		5	203
South	Dam	29				1	30
	Fall Creek	17				1	18
	Lime Creek	18					18
	Narrows	28				1	29
	Rock Creek	12			1		13
	Upper Res.	11					11
	Total	115			1	3	119
Grand Total	Grand Total	309	1	3	1	8	322

Table 5. Combined gill net catch by species from 18 nets fished in Anderson Ranch Reservoir on July 1-2, 2016.

Species	Catch #'s	Catch %	kokanee length (mm) Min	kokanee length (mm) Max
Chinook	6	1	150	474
Kokanee	433	80	54	537
Largescale Sucker	1	<1	124	124
Norther Pikeminnow	1	<1	593	593
Rainbow Trout	2	<1	210	280
Yellow Perch	95	17	7	267
Total	538	100	- -	- -

Table 6. Kokanee abundance estimates generated with trawl data by age class in Anderson Ranch Reservoir from 2003 to 2016.

Year	Age 0	Age 1	Age 2	Age 3	Age 4	All
2003	166,214	9,062	3,790	1,091	0	180,157
2005 *	526,307	46,828	19,318	5,217	0	597,670
2006	1,186,580	192,890	40,528	9,827	0	1,429,825
2007	692,704	841,421	97,832	66,645	0	1,698,602
2008	1,172,086	40,712	152,748	30,584	0	1,396,130
2009	431,627	57,410	15,021	10,134	0	514,192
2010	786,879	45,215	137,352	44,507	0	1,013,953
2011	2,632,168	108,117	28,146	12,319	3,335	2,784,085
2012	6,357,038	1,199,423	111,074	4,203	0	7,671,738
2014 *	109,717	15,540	103,228	14,970	0	243,455
2016 *,[a]	1,699,672	572,633	0	0	0	2,272,305
2016 *,[b]	1,171,088	398,754	0	0	0	1,569,842
Avg	1,411,007	294,000	59,086	16,625	278	1,780,996
Stdev	1,708,083	387,849	57,141	20,588	963	2,017,905

* denotes a break in annual sampling

[a] north trawl

[b] south trawl

Table 7. Kokanee density (fish/ha) estimates generated from trawl data by age class in Anderson Ranch Reservoir from 2003 to 2016.

Year	Age 0	Age 1	Age 2	Age 3	Age 4	All
2003	112	6	3	1	0	121
2005 *	348	31	13	3	0	396
2006	802	130	27	7	0	966
2007	554	673	78	53	0	1,359
2008	751	26	98	20	0	895
2009	280	37	10	7	0	333
2010	473	27	83	27	2	611
2011	1,582	65	17	7	0	1,671
2012	4,117	777	72	3	0	4,969
2014 *	76	11	71	10	0	168
2016 *,[a]	1,101	371	0	0	0	1,472
2016 *,[b]	758	258	0	0	0	1,017
Avg	913	201	39	11	0	1,165
Stdev	1,095	270	38	15	1	1,303

* denotes a break in annual sampling

[a] north trawl

[b] south trawl

Table 8. Kokanee abundance (#), density (#/ha), biomass (kg), and standing stock (kg/ha) estimates from two trawl configurations sampling in Anderson Ranch Reservoir on June 30, 2016

Trawl type	Estimate	Age 0	Age 1	Age 2	Age 3	Age 4	All
North	Abundance	1,699,672	572,633	0.0	0.0	0.0	2,272,305
	Density	1,101	371	0.0	0.0	0.0	1,472
	Biomass	3,248	31,082	0.0	0.0	0.0	34,330
	Standing Stock	2.1	20.1	0.0	0.0	0.0	22.2
South	Abundance	1,171,088	398,754	0.0	0.0	0.0	1,569,842
	Density	759	258	0.0	0.0	0.0	1,017
	Biomass	2,375	22,527	0.0	0.0	0.0	24,902
	Standing Stock	1.5	14.6	0.0	0.0	0.0	16.1

Table 9. Kokanee standing crop (kg/ha) estimates generated from trawl data by age class in Anderson Ranch Reservoir from 2003 to 2016.

Year	Age 0	Age 1	Age 2	Age 3	Age 4	All
2003	0.3	0.1	0.4	0.6	0.0	1.4
2005 *	0.8	4.1	3.4	1.0	0.0	9.3
2006	2.2	14.5	7.5	2.6	0.0	26.8
2007	1.1	35.4	9.2	12.3	0.0	58.0
2008	1.2	1.8	13.0	3.2	0.0	19.2
2009	0.4	2.6	2.5	2.2	0.0	7.7
2010	0.9	1.0	7.6	7.1	0.7	17.2
2011	4.5	4.9	4.8	2.6	0.0	16.9
2012	9.2	51.1	6.5	0.8	0.0	67.7
2014 *	0.1	1.5	16.9	2.9	0.0	21.4
2016 *,[a]	2.1	20.1	0.0	0.0	0.0	22.2
2016 *,[b]	1.5	14.6	0.0	0.0	0.0	16.1
Avg	2.0	12.7	6.0	3.0	0.1	23.7
Stdev	2.6	16.0	5.3	3.5	0.2	19.7

* denotes a break in annual sampling

[a] north trawl

[b] south trawl

Table 10. Trawl-generated kokanee biomass (kg) estimates by age class in Anderson Ranch Reservoir from 2003 to 2016.

Year	Age 0	Age 1	Age 2	Age 3	Age 4	All
2003	383	181	613	954	0	2,132
2005 *	1,205	6,223	5,079	1,517	0	14,025
2006	3,204	21,487	11,086	3,871	0	39,648
2007	1,307	44,254	11,503	15,407	0	72,471
2008	1,873	2,848	20,304	4,993	0	30,018
2009	589	4,067	3,861	3,415	0	11,933
2010	1,416	1,648	12,686	11,777	1,164	28,690
2011	7,525	8,189	7,939	4,386	0	28,040
2012	14,266	78,895	9,993	1,291	0	104,445
2014 *	154	2,154	24,482	4,260	0	31,050
2016 *,[a]	3,248	31,082	0	0	0	34,330
2016 *,[b]	2,375	22,527	0	0	0	24,902
Avg	3,129	18,630	8,962	4,323	97	35,140
Stdev	4,026	23,532	7,792	4,726	336	27,850

* denotes a break in annual sampling

[a] north trawl

[b] south trawl

Table 11. Rotenone application table for Lower Bruneau Dunes Pond treatment in October 2016.

Rotenone application rates (5.0% Active)		
Carp in organic rich environment	4	ppm
Active rotenone	0.25	ppm
Acft treated / 1 gal rotenone	0.75	acft

Fishery	Pool ID	Measure	Estimate
Bruneau Dunes lower pond	Pool #1	Ave. width (m)	265
		Ave. length (m)	972
		Ave. depth (m)	1.70
		Hectare/meters	44.53
		Total liters of product	1825

Table 12. Cost benefit analysis table for Bruneau Dunes lower pond rotenone application.

Method	Measure	Cost
Fixed wing aircraft	2 Aircraft	$4500.00
On the water treatment	Staff wages	$1416.00
	Fleet	90.50
	Equipment	1830.00
	Fuel	475.00
	Total	$3810.00

Table 13. Smallmouth Bass sampling indices for Magic reservoir from 2010 to 2016.

	Year		
Measure	2010	2012	2016
Ave. catch (CPUE)	0.6	11	9
Ave. length (mm)	185	212	163
Ave length at Age 5		284	381
PSD	17	21	22
RSD(S-Q)	83	79	77
Max. age (years)	4	11	5

Table 14. FWIN sampling indices from Oakley Reservoir 2007-2016, with gill nets.

	Year			
Measure	2007	2008	2009	2016
Ave. catch (CPUE)	26	37	19	35
Ave catch $\geq$ 450 mm	1.94	1.11	1.94	0.28
Relative Weight (%) (M)	85	85	84	82
Relative Weight (%) (F)	84	85	89	81
Ave. VFI	1.76	1.72	1.69	1.08
Ave. GSI	1.59	1.58	1.46	1.20
Max. age in Sample	17	17	19	13
Age classes present	13	11	11	11
FWIN Score	2.75	2.50	2.50	1.75

Table 15. Fall Walleye Index Netting (FWIN), from Oakley Reservoir. Benchmark Classification Scoring Parameters for 2016 sampling with gill nets.

2013 Score		Benchmark classification
Parameter	Value	Score
CPUE≥450	0.28	1
Age Classes	11	3
Maximum age	13	1
Female Div. Index	0.60	2
	Score	1.75

Parameter rank	Healthy/stable	Stressed/unstable	Unhealthy/collapsed
Score	3	2	1
CPUE≥450mm	≥2/net-1	0.44 to 1.99•net-1	≤0.43•net-1
No. of age classes	≥11 age classes	6 to 10 age classes	≤5 age classes
Maximum age	>16 years	14 to 16 years	≤13 years
Female Div. Index	≥0.66	0.56 to 0.65	≤0.55

Table 16. Comparative population estimates over the three reaches sampled in Silver Creek from 2001-2016.

Species	Site	Year	Pop est.
Rainbow trout	Stalker	2001	877
		2004	801
		2007	768
		2010	1227
		2013	1282
		2016	575
	Cabin	2001	7483
		2004	3433
		2007	2054
		2010	1059
		2013	5757
		2016	149
	Martin	2001	
		2004	
		2007	
		2010	
		2013	136
		2016	
Brown trout	Stalker	2001	1827
		2004	439
		2007	324
		2010	461
		2013	777
		2016	473
	Cabin	2001	2997
		2004	1727
		2007	366
		2010	457
		2013	1406
		2016	80
	Martin	2001	627
		2004	797
		2007	538
		2010	513
		2013	752
		2016	437

Table 17. Comparative density estimates over the three reaches of Silver Creek sampled from 2001-2016.

Species	Site	Year	#/km
Rainbow trout	Stalker	2001	1070
		2004	666
		2007	966
		2010	1686
		2013	929
		2016	416
	Cabin	2001	6236
		2004	4286
		2007	1726
		2010	910
		2013	5050
		2016	130
	Martin	2001	
		2004	
		2007	
		2010	
		2013	162
		2016	
Brown trout	Stalker	2001	2228
		2004	365
		2007	408
		2010	334
		2013	563
		2016	342
	Cabin	2001	2498
		2004	2156
		2007	308
		2010	303
		2013	1233
		2016	70
	Martin	2001	900
		2004	904
		2007	640
		2010	566
		2013	894
		2016	520

APPENDIX A.

SAMPLING EFFORT AND RELATED GEOREFERENCES

Water	Site	Gear	E	N	Z	Datum	Note
Anderson Ranch Reservoir	1	Trawl	359232	4786140	50	WGS84	Kokanee Trawl
	2		358263	4787848	50	WGS84	
	3		356915	4788586	50	WGS84	
	4		354808	4791808	50	WGS84	
	5		353084	4789946	50	WGS84	
	6		352215	4790688	50	WGS84	
	7		352455	4792016	50	WGS84	
	8		352050	4790825	50	WGS84	
	9		353217	4789914	50	WGS84	
	10		355612	4788871	50	WGS84	
	11		357025	4788676	50	WGS84	
	12		357859	4788080	50	WGS84	
Bruneau Dunes Large Pond	1	Rotenone	393298	4749957	50	WGS84	Rotenone
Lower Goose Creek Reservoir	1	Gill Net	711413	4665410	49	WGS84	FWIN Sampling
	2		711775	4664563	49	WGS84	
	3		711622	4665054	49	WGS84	
	4		711063	4665270	49	WGS84	
	5		711188	4665625	49	WGS84	
	6		691423	4749848	49	WGS84	
	7		688798	4823811	49	WGS84	
Magic Reservoir	1	EFish	278365	4786404	50	WGS84	Electrofishing survey of reservoir
	2		277616	4786574	50	WGS84	
	3		278144	4786708	50	WGS84	
	4		276789	4786506	50	WGS84	
	5		275889	4786034	50	WGS84	
	6		275553	4785584	50	WGS84	
	7		275098	4783990	50	WGS84	
	8		274126	4783921	50	WGS84	
	9		274467	4782377	50	WGS84	
	10		275044	4783230	50	WGS84	
Silver Creek	1	DEFish	7300007	4799575	11	WGS84	Stream survey
	2		7310010	4799098	11	WGS84	
	3		7345340	4800807	11	WGS84	

APPENDIX B.

EQUIPMENT

Fishery type	Equipment	Description
Lakes & Res.	Conductivity meter	Yellow Springs Instrument (YSI) model 30
	Depth sounder	Hondex© portable depth sounder
	Secchi disc	Standard; decimeter graduation
	pH meter	Oakton © hand held pH meter - Model 35624.2
	Power boat electrofisher	Clark Boat
	Boom	Aluminum (2.6 m-long)
	Anode	Octopus-style steel danglers (1 m-long)
	Cathode	Boat and cathode array danglers - simultaneous
	Live well	Fresh flow aerated; 0.65 m^3
	Oxygen stone	35.6 X 3.8 cm (135 m^2); fine pore
	Generator	Honda © ; model EG5000x; 5,000 watt
	Electrofishing control box	Midwest lakes ©
	Sinking gillnet	6 panels (19, 25, 32, 38, 51, 64 mm bar-mesh); 38 x 1.8 m; monofilament
	Floating gillnet	6 panels (19, 25, 32, 38, 51, 64 mm bar-mesh); 38 x 1.8 m; monofilament
	Walleye Gillnet (FWIN)	8 panel (25, 38, 51, 64, 76, 102, 127, 152 mm bar-mesh); 61 x 1.8 m, monofilament
	Trap net	1.8 x 0.9 m box, 5 - 76 cm hoops, 15.2 m lead, 2 cm bar mesh
	Seine	18 m x 1 m, 6 mm mesh 18 m x 1 m, 3 mm mesh
	Conductivity meter	Yellow Springs Instruments © (YSI); model 30
	Plankton nets	250, 500, 750 *u* mesh; 0.5 m diameter mouth; 2.5 m depth
	Temperature / D.O. meter	Yellow Springs Instruments © (YSI); model 550A
	Dip nets	2.4 m-long handles ; trapezoid heads (0.6 m^2); 9.5 mm bar-mesh
	Secci disc	Standard; decimeter graduation
	Thermograph	Onset-Tidbit© v2 temp logger.
	Field PDA	Juniper Systems ©, model Allegro handheld; waterproof, WinCE/DOS compatible

Appendix B cont.

Fishery type	Equipment	Description
	Scales	AND© 5000g electronic, OHAUS© 3000g, electronic Pesola © : , 300 g, 1 kg, 2.5 kg, 5.0 kg scales
Rivers and Streams	Power boat electrofisher	Driftboat.
	Raft	4.9 m-long rubber
	Anode	13.7 m-long power cord; 2.4 m-long fiberglass handle; 0.4 m diameter steel hoop
	Cathode	Boat
	Live well	208 L plastic garbage can; O_2 supplemented
	Drift boat	4.5 m-long aluminum
	Boom	4.3 m-long fiberglass
	Anode	Octopus-style steel danglers (1 m-long)
	Cathode	Boat
	Live well	208 L rubber stock watering tub; O_2 supplemented
	Scales	AND© 5000g,electronic, OHAUS© 3000g,electronic Pesola © : , 300 g, 1 kg, 2.5 kg, 5.0 kg scales
	Oxygen stone	35.6 X 3.8 cm (135 m^2); fine pore
	Generator	Honda © ; model EG5000x; 5,000 watt
	Electrofishing control box	Midwest lakes ©
	Oxygen stone	35.6 X 3.8 cm (135 m^2); fine pore
	Dip nets	2.4 m-long handles ; trapezoid heads (0.6 m^2); 9.5 mm bar-mesh
	Backpack electrofisher	Smith-root © model 15-D; single anode
	Conductivity meter	Yellow Springs Instrument © (YSI) model 30
	Thermograph	Onset-Tidbit© v2 temp logger.

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